MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS

IN 3 VOLUMES AND 8 PARTS

... LEVELER,

MENT

...AVY),

ETC.

BY

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PUBLISHERS' NOTE.

When announcement was made that these volumes were in preparation, inquiries and orders poured in very rapidly. In order to make the various parts available for the forthcoming examinations, the preparation of the manuscript, and the composition and presswork had to be completed with all possible haste, which accounts for the various typographical errors that have crept in, particularly in the case of Vol. II, Part 2. A sheet of errata has been prepared, and the publishers, as well as the authors, would thank the readers for calling attention to any other errors that may be discovered, which will be corrected in the next edition.

PREFACE.

"Civil Service" has had such a marked development during the past decade that it has come to be recognized as one of the important institutions in our civic life. In the Federal Service, as well as in that of many States and municipalities, thousands of positions which for years were under political control are now filled on the basis of merit and fitness as ascertained by competitive examinations.

Especially is this true in positions requiring knowledge of a technical character, and, in the City of New York alone, over two thousand persons hold civil engineering positions, the majority of which have been filled through the medium of competitive examinations. The widespread interest in these examinations has brought to editors of technical journals numerous inquiries concerning their scope, character, frequency, etc., requests for sample questions and for suitable books of reference. Considerable difficulty was experienced in answering many of these queries and in making recommendations, for, while excellent text-books were to be had, no single work was available containing the desired information.

The present book aims in a measure to fill the want that has been so long apparent.

Some difficulty was experienced in its preparation. To cover the whole field of Civil Engineering was impracticable, and another text-book would not materially aid the candidate. The authors therefore decided at the outset that the most appropriate information to include in a work of this character would be:

1st, Previous Examination Papers—giving as many sets as were readily available.

2nd, Typical Questions and Answers—such answers to be brief and to the point, and, while giving the information asked for, to avoid text-book discussion; in short, to indicate what may be expected of candidates in the examination room.

In the "Previous Examination Papers" the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers were not readily procurable, but they embody the substance of the questions asked.

The "Typical Questions and Answers" are not intended to be perfect or complete, as reasonable variance of opinion may exist as

to what is the best answer in many cases, owing to differences in interpretation of the question and in the education and experience of the candidate. In several instances, where questions on a given topic were few in number, the answers were intentionally enlarged upon.

Examinations are not always the best tests of merit and fitness, and they are never conclusive; but they must be employed for want of better means. Incompetent men occasionally succeed while others fail, such failure usually arising from lack of preparation. or inability to put on paper the requisite information in a given time. To the latter, the authors hope this book will prove useful, and also serve as a review and guide to engineers seeking to enter government employ. It is also hoped that the extensive collection of examination papers will prove useful to Civil Service Examiners in preparing new papers, and to instructors and students in engineering schools, for the purpose of quizzes and reviews, especially now that the introduction of Civil Service in the curriculum of such schools is being advocated.

As a matter of convenience, the book has been divided into eight parts, each complete in itself, the division being based upon the classification obtaining in New York City. As similar questions occasionally appear in the examination papers for different positions, it has been deemed advisable to repeat the answers, with due regard, however, to the requirements of the position. The parts were issued separately, and not in regular sequence, to render them available for the forthcoming examinations. For this reason the paging in the volumes is not consecutive. It is intended to remedy this in future editions.

Appendixes have been added to the first and second volumes, containing the formulas which appear in the text and some of the more common formulas with which the candidate should be familiar.

For those desiring information concerning examinations outside of New York City, an extensive appendix has been added, giving the Rules and Examination Papers for the United States Navy, Panama Canal and other Federal positions, the New York State Service, Boston, Buffalo and New Orleans, etc.

The work complete contains over one hundred sets of "Previous Examination Papers," comprising over two thousand questions and answers to about a thousand typical questions. Interleaving has

been introduced for the convenient addition of new sets and to provide space for notes, sketches, etc.

It may not be amiss here to say that the Civil Service of New York offers a broad and attractive field for engineers. The many public improvements under way and projected have necessitated the employment of a large number of technical men. Most of the candidates who pass the examinations receive appointment at fair salaries, and the opportunities for promotion and advancement are quite good.

Extracts from the rules and regulations governing the service in New York City and other pertinent data appear in the introduction.

The Authors are indebted to Mr. M. Feldman of the Department of Bridges for valuable assistance in the preparation of Volume III; to Mr. G. Harwood Frost, manager publication department, *Engineering News,* for advice and suggestions; to the Keuffel & Esser Co. of New York for the loan of many cuts.

Thanks are also due to those who kindly furnished copies of examination papers.

M. H. L.
M. K.

New York, October 1, 1906.

INTRODUCTORY.

The Civil Engineer Service of the City of New York forms one of the most important arms of its municipal organization, having under its direction the prosecution of public works involving a large part of the annual expenditures. This service embraces nearly 2 500 employees, most of whom, as stated in the preface, obtained their original appointment through competitive examinations. Positions in the lowest grades are filled by original appointment of successful candidates, and those in the higher by promotion, where possible. Owing to the lack of sufficient eligibles to meet the demands of the service, many examinations have been held during the past five years for the higher grades, and most of the successful candidates have received appointment. Applications for examinations are only received at stated times and on prescribed blanks, which may be obtained by addressing the Municipal Civil Service Commission, 299 Broadway, New York. The following table gives an idea of the classification, distribution and compensation of the Civil Engineering Employees. Extracts from the rules of the Commission follow the table, giving the pertinent information relative to Appointment, Promotion, Transfer, etc.

TABLE SHOWING APPROXIMATE NUMBER OF CIVIL ENGINEERING EMPLOYEES

IN THE CLASSIFIED CIVIL SERVICE OF THE CITY OF NEW YORK, JANUARY 1, 1906.

Position.	Finance, Tax and Law Departments.	Aqueduct Commission.	Board of Estimate.	Department of Bridges.	Department of Docks.	Department of Water Supply, Gas and Electricity.	Department of Parks.	Rapid Transit Commission.	Board of Water Supply.	President Borough of Manhattan.	President Borough of Bronx.	President Borough of Brooklyn.	President Borough of Queens.	President Borough of Richmond.	Board of Education.	Totals.	Compensation in most cases.	Remarks.
Assistant Engineers	6	27	6	35	18	34	4	88	15	20	49	34	26	14	....	376	$1 200 to $3 000 per annum.	Includes about 50 Chief and Division Engineers, salary $4,000 and over.
Transitmen and Computers	15	8	....	10	11	12	....	....	6	6	31	18	5	7	....	129	$1 200 to $1 800	
Draftsmen—(Structural, Architectural, Topographic and Mechanical)	29	....	1	17	24	23	1	25	6	6	31	29	46	20	130	388	$900 to $2 700	Majority, $1 200 to $1 800.
Levelers	....	14	....	7	10	16	1	....	5	5	18	8	1	25	....	110	$1 200 to $1 500	
Rodmen	....	18	8	6	10	14	2	100	15	5	31	12	5	25	....	246	$900 to $1 200	
Axemen	....	35	6	6	....	14	....	50	21	9	34	6	1	20	....	205	$720 to $900	
Inspectors—(Masonry, Building, Steel, Paving, etc.)	8	32	....	17	....	50	4	65	....	160	155	160	33	12	70	766	$4 to $7 per day; $1 200 to $1 500 per annum.	Does not include Plumbing, Sanitary, Pile Driving, and Tenement House Inspectors.
Totals	58	134	16	98	73	168	12	328	71	211	349	267	117	123	200	2 220		

*There has since been a large increase on the staff of the Board of Water Supply.

EXTRACTS FROM THE RULES OF THE MUNICIPAL CIVIL SERVICE COMMISSION OF THE CITY OF NEW YORK.

RULE VIII—FILING OF APPLICATIONS.

1. Applications for examination for positions in the Competitive Class shall be addressed to the Commission on a prescribed form, in the handwriting of the applicant, and accompanied by such certificates or other evidences as to citizenship, character, condition of health, education, previous employment, training and fitness as the Commission may require.

The statements of the applicant in these particulars shall be made under oath, properly attested.

2. Every application shall bear the certificate of four reputable citizens, whose residences or places of business are within the City of New York, to the effect that they have personally known the applicant for not less than one year, that they have read his statements and believe them to be correct, and that they will, upon request, give such further facts concerning him as they may possess, either for the files of the Commission or for the information of appointing officers.

If the previous occupation or employment of the applicant has been wholly or in part outside the City of New York, not more than two of the said certificates may be accepted, in the discretion of the Commission, from persons resident or engaged in business elsewhere; but no such certificate shall be accepted from a near relative of the applicant, or from any person the character of whose business, in the judgment of the Commission, may disqualify him as a fit voucher.

3. The Commission shall, by regulation or otherwise, fix the limits of time between which applications for a given examination shall be presented; but such period shall in no case be less than two weeks, and there shall be not less than five days between the last date for the presentation of applications and the date of examination.

4. An application presented within the prescribed limits of time, but found to be defective, shall be suspended, and notification shall be given to the applicant of the particulars in which it requires correction. Such an application shall be accepted if corrected and returned before the date of examination, but not otherwise.

5. Applications when presented shall be dated, numbered, and recorded in the order of their receipt. An application that has been accepted and filed shall not be returned for any reason to the applicant.

6. A person claiming rights of preference as a veteran shall file, with his application, proof of such veteranship and of his residence within the State of New York.

7. Application forms shall be furnished to intending applicants, upon personal or written request, at the office of the Commission, and shall be procurable there only.

RULE IX—MARKING AND RATING.

1. The examination papers shall be rated, in each case, by at least two examiners assigned therefor, who shall review them separately, and after such rating is completed shall affix to each a mark expressing the average of their judgment, attested by their respective signatures or initials. The marking shall be strictly comparative and according to such standards of proficiency as the needs of the service may require. Each subject shall be marked upon a scale of 100, which shall represent the maximum possible attainment.

2. Every candidate who receives a general average marking of not less than 70 per cent., and who has received not less than 20 per cent. in any required subject, or not less than 75 per cent. in any technical subject, when the examination is for a position of scientific, professional or technical nature, shall be eligible for certification and appointment in the manner, and under the conditions, hereinafter prescribed.

3. Where the Chief Examiner is satisfied, through investigation made under his direction, or otherwise, that the general character or the reputation of a candidate whose papers have been marked is not good, the name of such candidate shall not be placed on any eligible list; but all action under this clause shall be reported in writing, with the reasons therefor, to the Commission and shall be subject to the Commission's approval. The burden of proof of good character shall be upon the candidate who may, where doubt exists, be required to furnish evidence thereof additional to the certificates required at the time of his application.

4. The Secretary shall, as early as practicable after the completion of an examination, notify each candidate of the rating he has received, and of his relative standing, if such rating be above the minimum. He shall in the same manner notify any candidate who may be rejected for reasons other than failure to receive the minimum average, stating such reasons specifically.

5. A candidate receiving such notice may personally inspect his examination papers, in the presence of a designated officer or employee of the Commission, and, if he believes that any error or mistake in marking appears, or that injustice has otherwise been done him, may, not later than fifteen days after the date of such notice, file an appeal with the Commission, specifying particularly

the grounds of his complaint. The Commission shall take such action with reference to such appeal as substantial justice may require.

RULE X—ELIGIBLE LISTS.

1. The results of each examination shall be reported by the Chief Examiner to the Secretary, who shall enter the names of the persons passing, in the order of their average rating, on the proper list of eligibles; provided that the names of veterans so passing shall be entered, in the order of average rating, at the head of such list. The date of the establishment of a list shall be the date of such report.

2. When two or more eligibles on a list have the same average rating, preference in certification shall be determined by the order in which their applications were filed, or, if the examination be for promotion, by the order of their original appointment in the department or other division of the service in which the promotion occurs.

3. The term of an eligible list shall be not less than one year nor more than four years from the date of its establishment. An eligible list that has been in force for one year, except for the position of temporary clerk, shall terminate whenever a new list is established under the same title, and, in case of a graded position, for the same grade or grades.

Persons whose names appear on a list about to be terminated shall be notified of the new examination, in the same manner that applicants therefor are notified, and shall be informed that, upon the establishment of the new list, their original eligibility shall cease.

4. All eligible lists shall be published as early as may be practicable after their establishment, in the "City Record."

RULE XI—CERTIFICATION AND APPOINTMENT.

1. Selections for appointment to all positions in the Competitive Class not filled by promotion, reduction, transfer or reinstatement shall, except as provided in Rule XII, be made in the following manner:

The appointing officer shall notify the Commission of the title of the position, the duties to be performed and the compensation to be paid. The Commission shall thereupon certify to such appointing officer from the eligible list most nearly appropriate to such position, and for the grade thereof, if in a graded service, the three names at the head thereof; provided that, except in the case of a veteran, no such name shall be certified more than three times to the same appointing officer for the same or a similar position, unless at such officer's request. The relative rating of each candidate shall be stated in the certification, and, if the appointing officer requests, the application and examination papers of each shall be

submitted for his inspection, at the office of the Commission. Certification shall be made without regard to sex unless sex is specified in the requisition.

The appointing officer shall make selection, with reference solely to merit and fitness, from the three names certified, unless objection shall be made, and sustained by the Commission, to one or more of the persons named, in which case the certification of three names shall be completed by addition of the name or names next following upon the eligible list. If there be more than one vacancy to be filled, names shall be certified and selection shall be made for each of such vacancies in the same manner.

2. The person selected shall be duly notified by the appointing officer, and, upon accepting and reporting for duty, shall receive from such officer a certificate of appointment for a probationary period of three months; except in the Police or the Fire Service, where such period shall be one month. If his conduct or capacity on probation be unsatisfactory to the appointing officer the probationer shall be notified in writing that at the end of such period he shall, for that reason, not be retained; his retention in the service otherwise shall be equivalent to permanent appointment.

3. A probationer separated from the service for any reason other than fault or delinquency shall be restored to the eligible list from which he was selected, with the same relative standing, and the time during which he has actually served shall be deducted from the period of probation if he be again selected by the same appointing officer. When two or more persons selected from the same eligible list are serving as probationers under the same appointing officer, and a reduction of force is necessary, they shall be preferred for retention in the order of their original standing on such list.

4. The name of any person certified as eligible for a probationary appointment who shall decline such appointment shall be stricken from the list from which such certification is made, unless such declination be for one of the following reasons:

(*a*) Residence in a borough other than that in which the duties are to be performed; (*b*) insufficiency of the compensation offered, if such compensation be lower than the amount or the maximum amount stated in the announcement of examination; or (*c*) temporary inability, physical or otherwise, the evidences of which must be acceptable to and approved by the Commission and set forth in its minutes.

The failure of an eligible person to respond within four days to an offer of appointment sent to his post-office address shall be considered a declination.

An eligible who has declined appointment by reason of the insufficiency of the compensation offered shall not be again certified for a position at the same or any less compensation, and whenever

one or more eligibles shall have declined appointment to any position for such reason, and an eligible whose standing is lower is appointed thereto, the compensation of such appointee shall not be increased within one year thereafter beyond the amount offered to any person so declining.

On notification from an appointing officer that a person named in a certification has declined appointment, and on receipt from such officer of such declination in writing, or of evidence of the failure of such person to respond to a notice properly sent, such certification shall be completed by addition of the name of the eligible next in order.

5. No certification shall remain in force for a longer period than fifteen days. Until such certification has been exhausted or terminated no new certification shall be made for the same position, but the names of the persons certified may be certified for any similar position.

6. Every person selected for appointment shall be required to fill out and sign, in the presence of the appointing officer or his representative, an identification sheet, repeating the essential facts stated by him at the time of examination, which shall be forwarded to the Commission with the notice of appointment and filed with the appointee's application papers.

If a person who is not entitled to certification is certified and appointed, his appointment, upon due notification from the Commission to the appointing officer, shall be revoked.

RULE XIII—SUSPENSION AND REINSTATEMENT.

1. Whenever any permanent position in the Competitive Class is abolished or made unnecessary, or whenever the number of positions of a certain character is reduced, the person or persons legally holding such positions shall be deemed to be suspended without pay, and the names of such persons shall, on due notification from the appointing officer, be placed by the Commission on a special list, under such classified title and corresponding to such competitive eligible list as, in the judgment of the Commission, most nearly cover the class of duties performed by such persons in the position from which suspension is made. For a period of one year from the date of suspension such persons shall be entitled to reinstatement in any position, or any grade of such position, for which certification from such corresponding eligible list might be made, and the Secretary shall certify their names to the proper appointing officer as entitled to such reinstatement, in the order of the dates of their original appointment to the Classified Service, before certification is made from such corresponding eligible list for any such vacancy; provided that such persons shall be selected for certification, *first,*

for a position the same as that from which suspension was made, if the vacancy exists in such a position, and *second,* for corresponding or similar positions.

A person so certified who declines to accept a reinstatement, except for one of the reasons and under the conditions stated in subdivision 4 of Rule XI, shall be considered to be permanently separated from the service.

2. The provisions of the foregoing clause shall not apply to any person who resigns his position or who is suspended or removed therefrom for any reason other than those therein specified. Leaves of absence without pay may be granted by an appointing officer, without conflict with such provisions, where such absence does not exceed thirty days, or in case of sickness six months; but the Commission, in exceptional cases, the circumstances of which shall be stated in its minutes and in its annual report, may extend such periods. Absence without leave for a period of five days, unless it be subsequently shown that such absence was unavoidable, shall be construed as a resignation.

3. A person who has resigned from a permanent competitive position, or who has been removed or otherwise separated therefrom from any cause other than fault or delinquency on his part, may be reinstated without examination, at any time within one year from the date of such separation, in a vacant position in the same class and grade, provided that for original entrance to such position there is not required by these rules, in the judgment of the Commission, an examination involving tests or qualifications different from or higher than those involved in the examination for appointment to the position formerly held by such person. But no person shall be so reinstated who at any time within a year prior to the date of his separation from the service had been eligible for reinstatement as a suspended employee.

The Commission may in its discretion extend the period during which reinstatement may be made under this clause where the person seeking reinstatement resigned his position in order to serve in the Army or Navy of the United States in time of war, and has received an honorable discharge therefrom.

RULE XIV—TRANSFER.

1. A person who has been permanently appointed to a position in the Competitive Class may be transferred without examination to a similar position in such class, or to a position of the same grade thereof, if it be in a graded service, in any other department, office or institution; provided that for original entrance to the position proposed to be filled by transfer there is not required by these rules, in the judgment of the Commission, an examination involving tests or qualifications essentially different from or higher than those

required in an examination for original entrance to the position from which transfer is sought; or provided he shall have passed the examination or obtained a place upon the eligible list in force for such position; and provided further that if such person entered the service without competitive examination, and prior to the requirement thereof in the case of the position held by him, he shall have served with fidelity for at least three years in such position, or in a similar position.

2. A person may be transferred from a position in one class to a position in another class, or from a position in any grade of the Competitive Class to a different grade in such class, who has served a year in the position from which transfer is sought, under special authority granted by the Commission, for reasons to be stated in its annual report, and subject to the provisions of Clause 1 of this rule.

3. A person who, by transfer or promotion from a competitive position, is holding a position in another class or in another grade, and who has served continuously therein from the date of such transfer or promotion, may be retransferred, without the application of the foregoing restrictions, either to the position originally held by him, or to any position to which transfer could be made therefrom.

4. Upon the written request of an appointing officer, stating the facts with reference to a proposed transfer, accompanied by the consent, also in writing, of the appointing officer from whose jurisdiction the transfer is to be made, the Commission will, if such transfer be in accordance with law and the provisions of these rules, issue its certificate to that effect; but no such transfer shall be made or recognized until after the issuance of such certificate.

RULE XV—PROMOTION.

1. Vacancies in positions above the lowest grade in any Part of the Competitive Class, except Part I, that are not filled by original appointment, transfer, reinstatement or reduction, shall be filled by promotion, based, so far as practicable, on competitive tests.

2. Examinations for promotion shall be ordered as often as may be necessary to meet or to anticipate the needs of the higher grades, and, so far as practicable, shall be held periodically. Except where otherwise provided by law, such examinations shall be open, in each case, to all persons who shall have served with fidelity for not less than six months in positions of the same group or general character in the grade next lower, in the same department, office or institution; except that, for reasons to be set forth in its minutes, and where permitted by law, the Commission may open such examination to persons in two or more lower grades who shall have served

with fidelity for not less than six months in the periods held by them respectively.

Notice of such examination shall be given by the Secretary to all eligible persons in the grade or grades from which promotion is to be made at least one week in advance of the date thereof.

3. A position in any of the aforesaid Parts the compensation of which is not identical with that specified in the Classification for any grade of such Part shall, for purposes of promotion, be deemed as of the grade the compensation of which is specified as next lower than the compensation paid.

6. The subjects of rating and the relative weights thereof, in any competitive promotion examination, shall be as follows: For seniority of service in the position or grade from which promotion is sought, 20; for comparative conduct and efficiency in previous service in such position or grade, 40; and for written papers on pertinent subjects, 40; provided, that in rating for seniority, where more than one grade is opened, such rating shall be based upon the service of a candidate in all of such grades; and provided further that the maximum term of service in a position or grade to be considered in rating for seniority shall be fifteen years.

RULE XVI—REMOVALS.

1. No person holding a position in the service of the city shall be removed from such position, except in the manner prescribed by the Charter and the Civil Service Law; and the officer charged with the power of removal, in each case, shall transmit to the Commission, with the report of his action required under Rule XX, a copy of the reasons therefor, or of the findings of any trial board or officer, as stated to the person removed, and as filed in the department or office.

2. No person who is an honorably discharged soldier, sailor or marine, having served as such in the Union Army or Navy during the War of the Rebellion, or in the volunteer army or navy of the United States during the Spanish War, or who is a veteran volunteer firemen, shall be removed from any position in the Classified Service except in the manner prescribed by section 21 of the Civil Service Law.

3. The provisions of this rule shall apply to the removal of any person from a graded position by reduction to a position in a lower grade, but shall not apply to a suspension from service for lack of work or reduction of force.

(U8290)

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IN 3 VOLUMES.

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, AND TRANSITMAN AND COMPUTER.

VOL. II. ASSISTANT ENGINEER.

VOL. III. DRAFTSMAN, AND INSPECTOR.

VOL. I. PART I.

AXEMAN.

INDEX.

NEW YORK:
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PREFACE.

In the "Previous Examination Papers" which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of the questions asked.

In the section devoted to "Typical Questions and Answers," the answers indicate in a general way only what is required of the candidate, and are not intended to be perfect and complete, as reasonable variance of opinion may exist as to what is the best answer in many cases, owing to differences in interpretation of the question and in education and experience.

In order to perpetuate the value of this book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved, to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

PRELIMINARY EXAMINATION, RAPID TRANSIT COMMISSION.

Technical Paper.

New York, October 9, 1899.

Salary, $1 200.

1. (*a*) What do you understand by the term "angle of repose" of earth? (*b*) Where is the center of pressure in a retaining wall, earth level with top?

2. (*a*) Within what limits should the line of thrust come in the abutment of an arched bridge to insure stability? (*b*) What should be the proportion of "headers" to "stretchers" used in a retaining wall?

3. What pressure per square foot can safely be placed on the following materials when ground is continually wet: (*a*) clay, (*b*) loam, (*c*) gravel?

4. What is the difference between refraction and reflection and what is the effect of the former on the line of sight of a level?

5. In running a line of levels with sights 1 600 ft., what method would you use to insure accuracy and allow for refraction and curvature?

6. What are the physical properties of cast iron, wrought iron and wrought steel, that make them useful in engineering works? State briefly how they should be tested and what uses they are best fitted for.

7. Give essential points in specification for timber piles and pile driving.

8. What are the various ways of using and shaping sheet piling to keep water away from work?

9. What is hydraulic cement and how should different samples be tested?

10. Write monthly estimate for some public work, giving at least six items, carry out the arithmetic, assume prices that you believe correct for such work, show amount retained, previous payments, etc.

Mathematical Paper.

1. Given a culvert; what will be the cubic feet per second of water reaching the culvert draining 1 000 acres? Assume formula as follows:

$$Q = c\,y\,\sqrt[4]{s\,a^3}$$

Q = Cubic feet per second reaching culvert.
c = Proportion of rainfall.
y = Rainfall per hour in inches.
s = Slope in feet per 1 000 ft.
a = Number of acres drained.

Assume values for c, y, and s according to your judgment.

2. If 12 men shovel 90 yd. of earth in one hour and a half, how many men will be required to shovel 2 500 yd. of earth in ten hours?

3. Extract square root of 49 783.96.

4. Given a pair of rafters, span 50 ft., angle 30°; what will be the length of rafters and strain on each?

Report Paper.

Write a report, covering at least two pages, on some important work, stating design selected, reason for selecting it and report progress in the work up to a certain period. Give such information as the chief engineer would expect to find in such a report.

Experience Paper.

1. Have you pursued a course of study in any school or college which fits you for the position of assistant engineer; if so, give length of course? Did you graduate or receive a degree or diploma?

2. Have you ever taken a course of study with an engineer?

3. Have you any mechanical experience?

4. State what experience you have had, especially in public work.

5. State any further experience that you may think important.

PRELIMINARY EXAMINATION,

RAPID TRANSIT COMMISSION.

TECHNICAL PAPER.

NEW YORK, May 14, 1900.

Salary, $1 200.

1. Sketch a retaining wall, showing the angle of repose of earth. (*b*) Show the line bounding the prism of maximum pressure. (*c*) State the relation of the vertical angles bounded by those two lines. (*d*) Draw the diagram of forces acting upon the wall and state the position the resultant must take in order to insure stability.

2. (*a*) In what order do earths arrange themselves as to thrust, stating that with the least thrust first? (*b*) State the several conditions that will change the amount of thrust of earth.

3. (*a*) In the flow of water through channels and conduits, state the several causes of resistance to flow. (*b*) What is the principal cause of resistance to flow in long pipes?

4. What is meant by "mean hydraulic radius"?

5. (*a*) In a rectangular wall, at what point is the pressure of water applied? (*b*) How would you obtain the total pressure of water against the wall?

6. What is meant by "limit of elasticity" and what is the relation of the limit of elasticity to ultimate strength in steel and iron?

7. How will riveted joints fail in thin and thick steel and iron?

8. What is meant by the degree of a curve?

9. Having given the degree of a curve, how would you lay it out on the ground?

10. What instruments do you consider essential and desirable to make a survey of the subway?

11. What error would you expect in running levels a distance of a mile in a crowded street?

12. (*a*) How would you establish transit points? (*b*) State in this the establishing of transit points on block pavement?

13. If the line of the subway runs through several blocks and underneath the houses, how would you make a survey showing accurately the intersection of the line of the tunnel with all property lines?

14. What are the principal difficulties in making a survey through the city streets?

15. Show a specimen form of note-book for a survey of the subway under the streets through two blocks entirely built up.

Mathematical Paper.

1. Extract the square root of 10 873.2475.

2. What is the weight of a cast-iron column whose outside diameter is 12 in., thickness $\frac{3}{4}$ in. and length 13 ft. 6 in., allowing $11\frac{1}{2}\%$ additional for the base and cap?

3. A load of $70\frac{3}{8}$ tons is transmitted by an iron pedestal 3 ft. square upon a granite pier; the weight upon the earth under the pier shall not exceed 1 760 lb. per sq. ft.; the steps of the granite courses shall not exceed 1 ft.; the thickness of the courses is 2 ft.; what are the dimensions of the bottom course and what are the contents in cubic yards of the granite pier?

4. A train moving at the rate of 36 miles an hour is three-quarters of an hour ahead of another train moving at the rate of 42 miles an hour; in what length of time will the second train overtake the first?

5. A rectangle has an area of 60 sq. ft., its perimeter is 34 ft.; find the length of the sides.

Report Paper.

Write a report and specification for refilling the top of the subway in tunnel and paving the surface of the street with granite blocks.

PRELIMINARY EXAMINATION,
RAPID TRANSIT COMMISSION.

TECHNICAL PAPER.

NEW YORK, May 19, 1900.

Salary, $1 200.

1. In a retaining wall with a load of earth filling, how far back from the wall will a load have no effect and why?

2. In what manner do retaining walls fail? State different conditions.

3. When trench for wall has been dug to right depth, what is the next step?

4. In formulas for flow of water in channels, how is fall in water surface taken account of?

5. In a tank filled with water, find stress in hoop 1 ft. from the bottom.

6. Sketch uniformly loaded beam. Show reaction of support in terms W, L, D, etc., and moment at center.

7. State distinction between long and short columns and state how each fails.

8. Two tangents to be joined by curve; show what field notes should be taken and how the elements of curve are determined.

9. Describe method of transferring line from surface through shaft to tunnel.

10. Describe best method of fixing center line and grade in tunnel.

11. Give sketch of record notes for survey for subway for location of center line and property lines through two built-up blocks.

12. How should the work be left at night on the end of a sewer under construction?

13. Sketch center of 20-ft. arch (dimensions approximate).

14. A heavily loaded column rests on a granite block, 18 in. by 18 in., this block being the top of a pier 3 ft. high resting on earth, pier to be stepped off in three steps 1 ft. in depth; how would you find the width of each step; give reasons?

15. Give precautions to be used in laying brick work when great strength is required.

RAPID TRANSIT COMMISSION. CLASS (B).

MAY 26TH, 1900.

Salary, $1 500.

1. Give age, technical education, and name of institution of which you are a graduate, if any, and name all positions you have held, with length of service and character of work.

2. Name all precaution for sighting a line in a tunnel and what is the best means of eliminating errors in prolonging a line in a tunnel?

3. What information beside center line and grade are necessary before starting work on a tunnel?

4. If center line runs under blocks of houses, what information is needed other than in above question?

5. How could filling of trench over arch affect the stability of the latter?

6. What would an inspector keep record of: (*a*) On tunnel work? (*b*) On elevated railroad structure?

7. What methods and precautions are necessary in excavating rock, including blasting and all details in vicinity of houses, and what when water pipes are present?

8. Give a sketch of sheet piling and timbering with all dimensions for trench 25 ft. deep for sewer, external diameter 4 ft.

9. State all conditions for securing best work in masonry construction (closeness of joints and pointing of blocks not meant).

10. (*a*) Give full description of operation of mixing concrete by hand. (*b*) Describe any mechanical mixer with which you are familiar.

11. Upon what does bearing power of piles depend; what precautions should be used in driving piles, and how would you find safe bearing power theoretically?

12. (*a*) How would you unite a new layer of concrete with old? (*b*) What is gained by storing Portland cement before using it?

13. Give safe bearing powers of: (*a*) Gravel. (*b*) Good clean sand. (*c*) Loam?

14. What is the condition of arch sliding at the springing and in what form of arch is this most likely to occur?

15. What condition of failure of rectangular wall is shown by (*a*) vertical cracks, (*b*) forward movement as a mass, (*c*) horizontal cracks and bulging? And what remedies would you use in each case?

16 to 20. Give report and careful sketch of design for foundation of subway, where ground is such as to require piles or timber construction. State the best means of controlling flow of quick-sand where such is encountered in trench. Give form for estimate of quantities and prices for each item.

RAPID TRANSIT COMMISSION. CLASS "C."

MAY 26TH, 1900.

Salary, $1 800.

1. Give date and place of graduation from technical college, if any; place, length and character of each important engagement since.

2. Under what conditions as to nearness of excavation, depth, character of soil, etc., would you consider it necessary to underpin buildings on the line of subway?

3. Give essential features of process of underpinning a large water main so as not to interfere with its use.

4. Describe briefly operation of supporting and moving a large water main so as not to interfere with its use.

5. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

6. How would you arrange reports for your inspectors or other subordinates so as to obtain correctly the actual cost of any portion of the work?

7. Give an itemized example of this: (*a*) Ironwork, (*b*) stone masonry, (*c*) concrete.

8. Give all the points to be observed in the use of asphalt in waterproofing to insure compactness, freedom from blow-holes, thorough adhesion and sound work.

9. Describe the distinctive characteristics of foundations best adapted to the following sub-soil conditions: (*a*) Stiff gravel, (*b*) wet, soft mud becoming stiffer as depth increases, (*c*) soft mud with hard gravel 15 ft. beneath, (*d*) wet but confined and compact sand.

10. What are the advantages of a grillage of layers of steel rails set at right angles in concrete for a footing of a retaining wall? Show design for such a footing.

11. How would you provide for expansion and contraction in a long concrete retaining wall?

12. How many barrels of cement, yards of sand and tons of broken stone are required for 10 yd. of concrete of proportions 1, 3 and 5?

13. Give precautions to be taken for the health of assistants or laborers working under pneumatic pressure at a depth of 75 ft.

14. What is meant by "cut and cover" method in open cut construction and what is gained by it?

15. (*a*) What is the theoretical method of determining the safe bearing power of piles? (*b*) What modifications under different conditions? (*c*) Give practical method of determining the bearing power of piles.

16 to 20. Make a report and careful sketches of a proposed method for carrying the tunnel under the Harlem River. State what would be done in passing through different materials such as silt, clay or rock. Give itemized notes for estimate with approximate value of items.

ASSISTANT ENGINEER, RAPID TRANSIT.

Salary, $1 200. 1901.

1. Make a rough sketch of bracing, etc., in digging a double shaft 10 by 20 by 60 ft. deep. Give dimensions.

2. Make a sketch of a center for an arch with 20-ft. span, giving dimensions.

3. Describe the method of tunneling by shield.

4. Also by blasting.

5. Describe the method of triangulation to locate a tunnel, as East River tunnel and approach.

6. What are the principal requirements in relaying an asphalt pavement?

7. In relaying block pavement?

8. What is done with water in a tunnel below the level of a sewer?

9. How would you get a sight in a tunnel?

10. (*a*) How is a line prolonged accurately? (*b*) How is an angle turned accurately?

11. What are the requirements for substantial stone masonry?

12. Under what conditions can wood be used in permanent constructions?

13. Where and how would you locate a bench mark and point in a tunnel?

14. If a brick sewer is to be replaced by a number of cast-iron pipes so as to pass under a subway, how are their size and number determined?

15. What do the specifications call for in regard to the storing of material?

ASSISTANT ENGINEER, GRADE "A."

DECEMBER 8TH, 1902.

Salary, $1 200.

1. How would you lay out work for subway trench when work is in open cut?

2. (*a*) How would you give grade and line in tunnel? (*b*) How would you proceed when artificial light is used?

3. Give force and material account for keeping track of work from day to day.

4. How would you determine spacing of iron bents on curve?

5. When water is being pumped from beneath foundations, how would you determine whether or not settlement is likely to occur?

6. How would the engineer proceed to inspect roof of a rock tunnel after a blast?

7. A single large sewer is replaced by three smaller ones; is it sufficient to make new area equal to old? Explain fully.

8. Sketch a timber center for semi-circular brick arch, 25-ft. span.

9. Give quick rough test for cement in field, without the use of machine.

10. What are the requirements for good work in building a brick sewer?

11. How would you inspect a job of riveting?

12. For driving piles in quicksand, is it better to use quick, light blows, or slow, heavy ones? Explain reasons.

13. In back filling trench, what is the best arrangement of shovelers and rammers to get the best results?

14. How is work in tunnel conducted? (New York Subway.)

15. Write a careful report on a pile foundation and masonry pier for a bridge.

MATHEMATICS.

1. Extract square root of 30 001.94.

2. Four numbers whose sum equals 900; the first plus 2, the second minus 2, two times the third, and the fourth divided by 2, are equal. What are the numbers?

3. A trapezoidal field; parallel sides 18 ft. and 28 ft. The perpendicular distance between them is 42 ft. How far from the longer parallel side is a line dividing the field into two parts of equal area?

4. Two numbers whose sum is 6. The sum of their fifth powers is 1 056. What are the numbers?

ASSISTANT ENGINEER.

Salary, $1200. APRIL, 1903.

1. As applying to Rapid Transit Railroad construction, describe how you would transfer a bench mark from a point 200 ft. off the line to and down a tunnel shaft to a point 400 ft. within the tunnel.

2. The same for a transfer of a transit line to a P. C. in the tunnel.

3. Show by a sketch and describe a typical vertical section of a double track tunnel where it is necessary to keep close to the surface, including important dimensions and indications of materials used.

4. Show by plan and horizontal cross-section just above the track (double) the arrangement of answer to (3) assuming curve to a tangent at right angle.

5. State or show by sketch why side clearances on curves in tunnels must be greater than on tangents and calculate how much for a 60-ft. car with 40-ft. center to center of trucks.

6. Describe how the standard railroad track is best maintained in line and grade.

7. Describe "damp proofing" and its method of application.

8. Describe the method of transmission of electrical power by a third rail. State its advantages and disadvantages. (*b*) What are the important details of mixing and laying concrete to secure good work? (This does not refer to proportions of material.)

9. Assume data you consider reasonable and determine the external pressure on a steel tunnel tube 12 ft. in diameter running beneath 100 ft. of water, supported above bottom.

10. Outline specifications for stone and laying of first-class ashlar granite masonry in a heavy retaining wall.

11. State what you know of concrete steel and its advantages.

12. How is condensation prevented on roofs and station walls?

13. State everything necessary to secure the best cement mortar joints in brickwork, such as important sewer construction.

14. Show by sketch and description the method of sheeting a tunnel shaft (vertical) 12 ft. wide, 60 ft. deep throughout.

15. Write a report of not less than three nor more than four pages concerning the examination and method of shoring and placing in a sound condition a building which had partly settled due to excavation of R. T. tunnel.

Report.

Write a report of not less than two nor more than three pages on the probable causes of cracking of the roof and settling of the sidewalks of a tunnel (subway).

Mathematics.

1. Extract square root to four decimals of 629,514,455.084.

2. The center line of a portion of a circular street subtends an angle of 30° at the center, the raidus being 530. If the street is 60 ft. wide, find the area in square yards of the portion of the street.

3. Add the following, giving the answer in feet and decimals:
$6'-7\frac{1}{2}''$; $7'-3\frac{3}{16}''$; $8'-2\frac{13}{31}''$; $11-7\frac{1}{8}''$; $21-11\frac{9}{16}''$; $0'-6.5''$; $12'-7''.35$.

4. Find the volume of masonry in the roof of a tunnel 2 ft. thick with a semi-elliptical section with radii of 36 ft. and 20 ft., the portion being 100 ft. long.

ASSISTANT ENGINEER,

RAPID TRANSIT COMMISSION.

JUNE 8, 1904.

Salary, $1 200.

1. What are the precautions necessary to accurately measure a line, such as a base line for a triangulation survey?

2. What are the important points to be observed by a leveler in doing accurate leveling?

3. Same for a rodman.

4. State in their order the adjustments of a transit which also has an attached bubble for leveling.

5. Except for base line measurements, describe how an important triangulation would be done across the East River for the purposes of tunnel construction.

6. In designing of coursed ashlar masonry retaining walls, state briefly the theory of pressure and the methods of calculation.

7. In the construction of the same, state the precautions necessary to minimize the pressure and to secure sound and permanent work.

8. In concrete work, what are the important points: (*a*) in fixing the proportions; (*b*) in mixing; (*c*) in placing—all for high-class work.

9. Outline briefly the principles involved in the reinforcement of concrete-steel.

10. Show by sketch, with dimensions, a pile foundation for heavy masonry walls.

11. Describe briefly a good roadbed and track construction suitable for Rapid Transit subway.

12. State the prismoidal formula and illustrate its use by cross-section of an earth railroad embankment.

13. Show a monthly contractor's estimate covering open cut earth and rock excavation, concrete footing, brick masonry, steel built columns and beams; use approximate ruling prices.

14. Describe the method of tunnel construction in gravel and clay 50 ft. below water level.

15. Show by sketches, giving general dimensions and size, the method of construction of the lumber work of a double tunnel shaft 8 by 20 ft. and 60 ft. deep, in earth.

Report.

Write a report of not less than two nor more than three pages on the probable cracking of the roof and settling of the side walls of a tunnel.

PROMOTION EXAMINATION FOR ASSISTANT ENGINEER OF THE RAPID TRANSIT COMMISSION.

DECEMBER 14, 1905.

Salary, $1 200.

1. Transfer center line from surface to bottom of shaft 15 ft. wide, 20 ft. deep.

2. In measuring a long distance with a 100-ft. tape, what five precautions are necessary to get accurate work?

3. Subway running through street where two-track surface road and elevated structure are located. How will you support the street and "L" columns so as not to interrupt traffic on road; "L" columns set on curb 6 ft. inside of retaining walls of subway.

4. What is the relation between two rails on a transverse section of track on curve? Give reasons.

5. The subway crosses a 10-ft. circular sewer with a 0.5% grade, the sub-grade of subway 2 ft. above invert of sewer. How would you provide for sewerage without diminishing capacity?

6. What is the relation between velocities in circular pipes full, nine-tenths full, one-half full, one-quarter full?

7. What precautions would you take in blasting rock in open trench for the protection of adjoining property and persons?

8. What precautions should be taken in mixing and placing concrete (*a*) in ordinary foundation, (*b*) reinforced concrete arch, (*c*) when concrete is mixed with temperature below 30° Fahr.?

9. What precautions should be taken when assembling steel to make a good job?

10. How would you set stone bases for columns and what precautions?

11. How would you set granite block pavement on concrete base?

12. How would you prepare concrete for asphalt and what special precautions should be taken?

13. Figure thickness for a steel pipe 300 lb. pressure, 24 in. diameter, steel at 60 000 lb., factor of safety, five.

14. In back filling trench, what precautions are necessary to prevent or minimize future settling?

15. How would you prepare metal for painting and in what condition of weather should paint not be applied?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

CIVIL SERVICE OF THE CITY OF NEW YORK

TYPICAL QUESTIONS AND ANSWERS

ASSISTANT ENGINEER,

RAPID TRANSIT COMMISSION.

TYPICAL QUESTIONS AND ANSWERS.

1. What is the best way to fix the center line in tunnel?

Where the tunnel is in rock, by drilling holes in the roof and driving wooden or metal plugs provided with hooks, from which plumb bobs are suspended. Where timber bents are required to support the roof, nails or hooks may be driven in the timbers to fix the center line.

2. How would you carry the center line down a shaft and into tunnel? Explain every step and everything required.

The center line is first run on the surface, points being set very accurately, and repeatedly checked on both sides of the shafts. These points should be of permanent character. Horizontal cleats are fastened to the shaft timbers and the center line marked on them. Heavy plumb bobs weighing about 35 lb. are suspended from these points by fine piano wires. The bobs are steadied by being immersed in oil. The distance between these wires should be as large as the shaft will permit.

Set up transit in tunnel accurately on line with these two suspended wires and prolong the line, setting points ahead or behind as required, "double centering" with the instrument.

3. (*a*) When in tunnel how would you establish lines and grades? (*b*) How would you prolong the same where artificial light is required?

(*a*) Center lines are established in the roof of the tunnel as described in Question No. 1; sometimes in the bottom (where conditions permit).

Grades are established by marking points on the side walls or on ledges a whole number of feet above the grade of the tunnel.

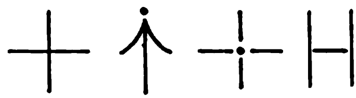
(See also Q. No. 6.)

(*b*) Where artificial light is required, the sights and instrument are illuminated with a candle, lamp or electric light provided for the purpose, the ordinary method of prolonging lines being used.

Special sights with illuminated slits set accurately on line may be used for alignment.

4. How would you mark center line of tunnel? (*a*) In open field, (*b*) on block pavement, (*c*) on asphalt pavement, (*d*) on rock, (*e*) in tunnel.

(*a*) By means of large hardwood stakes driven firmly in ground, line being marked by tacks. If the center line falls on exposed rock surfaces, suitable marks are cut in same, such as + ↑ -¦- H. Stone



monuments or concrete blocks with copper bolts should be set about every half mile.

(*b*) On block pavement, cut marks on the blocks as indicated above, or drive spikes in the joints, or blocks may be removed and spikes or stakes driven in foundation and recovered.

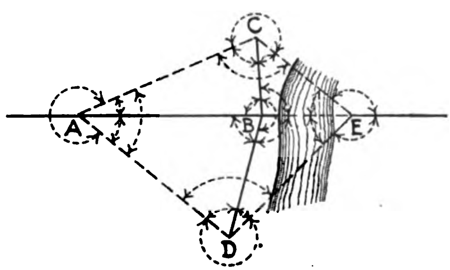
(*c*) Drive spikes through the asphalt or remove section of asphalt, drive stake underneath and replace with brick or loose material.

(*d*) By marks as designated in (*a*) or by metal plugs set in holes drilled in the rock.

(*e*) For marking center line in tunnel see Question No. 1.

5. How could you carry the center line of tunnel (*a*) across the East River, (*b*) down a shaft and into tunnel?

By triangulation as follows:



A B is portion of center line already established on one side of river.

Prolong line to *E* on opposite shore by double centering, making several trials. This fixes a point on line on the opposite shore.

The stationing of this point is obtained by triangulation. (See diagram.) The distance, *A B*, is accurately known. *C* and *D* are selected to give well conditioned triangles.

Read the angles as shown by the arrows. Calculate *B C* and *B D* and then *B E*, from which the stationing of *E* is obtained. The line is then prolonged from *E* in the usual manner.

(*b*) See Question No. 2.

6. Where and how would you locate the bench mark in a tunnel?

In rock tunnels bench marks should be located on ledges in the side walls, where they can be seen from both directions and not apt to be disturbed by the tunnel operations.

In earth tunnels, or in rock tunnels where timber is used to support the roof, spikes are driven near the foot of the most rigid posts, observing that the rod can be held vertically on same and that the rod can be seen from both directions. They should be well marked and described for identification.

7. As applying to Rapid Transit subway construction, describe how you would transfer a bench mark from a point 200 ft. off the line to and down a tunnel shaft to a point 400 ft. within the tunnel.

First transfer the bench mark to a point on one of the shaft timbers at the surface. With the aid of a steel tape, this bench mark is transferred to the bottom of the shaft at a point vertically beneath, the bottom being prepared for the purpose. This tape measurement should be repeated several times and the mean taken, thousandths being estimated. Using this new point as a bench mark, the levels are run in the usual manner, establishing bench marks as conditions require. Artificial light should be employed if necessary.

8. The same for the transfer of a transit line to a P. C. in tunnel.

Transfer the tangent from the surface to the tunnel as described in Question No. 2. The stations at the points of suspension of the bobs should be very accurately determined and this stationing applied to the points vertically beneath at the bottom of the shaft. The P. C. is then located in the usual way from the points thus established.

9. Besides the location of property lines and center line, explain what a complete examination of the tunnel route should consist of, especially under buildings and where tunnel crosses a stream.

The examination should show the character of the material along the route of the tunnel, whether rock, earth, made land, etc., as determined by numerous borings; all underground obstructions, such as sewers, water and gas mains, electric conduits, etc.; character of pavements; nature and extent and depth of building foundations and the underlying material; the character of the buildings, their height and construction. Understreams, the examination should show high and low water range, the depth at the bottom, the character of the material in the bed of the stream to prescribed depths, determined by borings.

10. When the rapid transit road is to be in open cut, how would you lay out the work previous to beginning the excavation?

Run an offset line, preferably parallel to the center line of the tunnel. This offset line should be outside of the neat lines of the excavation and where not likely to be disturbed by the work.

Offsets to the center line, from the house line, the curb line, or from the offset line itself, are marked on the face of the curb, sidewalk or other suitable place for the guidance of the foremen, as also the depth of cut to subgrade of excavation.

11. Where two tangents are to be joined by a curve, state what field notes are taken and generally what elements of curve are found?

Notes taken:
Bearing of tangents.
Angle of intersection of tangents.
Sta. at P. I.
Stations occupied by instrument.
The following elements of the curve are found:
Degree of curve.
Radius of curve.
Length of curve.
Deflection angles.
Tangent distances.
Stas. of P. T. and P. C.

12. What is the difference between "refraction" and "reflection" as applied to light, and how does the former affect the line of sight taken through a level?

See Leveler. Vol. I, Part III.

13. Suppose you had in leveling to take 1 600 ft. sights; how can you do it with reasonable accuracy and eliminate effects of curvature and refraction?

By taking equal back and foresights and repeating and averaging rod readings.

14. Why is not running the lines by the magnetic needle an accurate method?

Because the graduations on compass box are not adapted for accurate reading, and because local attraction and magnetic disturbances affect the needle.

15. What is the reason, if any, for taking the magnetic bearing of lines in making a survey?

As a check on the angles measured between courses of the survey.

16. What is the method for calculating areas from traverses?

Compute the double meridian distances of the courses and multiply them by their respective latitudes. Take the algebraic sum of these products and divide by two.

17. What is the greatest allowable error in precise leveling 4 miles?

About .05.

18. What is a fair closure of 20 angles in a traverse?

One minute.

19. What is your method of calculating earthwork?

For ordinary calculations use the average end area method. This consists of computing areas of cross-sections taken at suitable stations, averaging these areas successively, multiplying by their corresponding distances apart, and adding the products.

20. Give the safe bearing power of gravel, good, clean sand, loam, clay, hardpan, rock.

Gravel	5 tons per sq. ft.
Good, clean sand	4 " " " "
Loam	1 " " " "
Dry clay	3 " " " "
Wet clay	2 " " " "
Hardpan	8 " " " "
Rock in ledges	36 " " " "
Rock in beds	240 " " " "

21. (*a*) In what order do earths arrange themselves as to thrust, stating that with the least thrust first? (*b*) State the several conditions that will change the amount of thrust of earth.

(*a*) (1) Compact gravel, (2) dry clay, (3) moist earth, (4) dry sand, (5) wet clay.

(*b*) Earth thrust will be changed by presence of water in backing, vibration and jar due to traffic, superimposed loads on earth backing, frost, settlement and manner of depositing the backing.

22. In taking loamy earth from a borrow pit, what difference in cubical contents will there be between the borrow pit and the complete fill?

About 12 per cent.

23. What is meant by "limit of elasticity," and what is the relation of the limit of elasticity to ultimate strength in steel and iron?

The limit of elasticity is the point up to which the strain of the material is proportional to the applied stress. Any additional stress

will produce permanent deformation. *In steel and iron the elastic limit is about one-half the ultimate strength.*

24. How will riveted joints fail in thin and thick steel plates?

In thin plates failure may take place by:
1. Shearing of plate.
2. Crushing of metal about rivets.
3. Shearing of rivets.

In thick plates:
1. Shearing of rivets.
2. Bending of rivets.

25. Under what conditions can wood be used in permanent construction?

It can be used for work under water. It must not be exposed to the air at any time. It must also be protected from the teredo or other destructive forms of aquatic life.

26. What is hydraulic cement and what are its properties and uses as regards engineering construction? Outline briefly the methods by which you would test the relative merits of two or more samples.

Cement which possesses the property of hardening under water is called hydraulic cement. Hydraulic cement sets slowly and attains great strength. It resists the action of the weather. It is made of a mixture of lime and clay, natural or artificial, pulverized and burnt to vitrification.

Its main properties are that it sets in air or in water and attains great strength which increases with time. It is used as a cementing material in masonry structures and in the manufacture of artificial stone, concrete, etc.

27. What are the physical differences between American Portland and Rosendale cements? How are they manufactured?

Physical Differences.

Portland Cement.	*Rosendale Cement.*
Texture—Close, floury.	Porous and globular.
Color—Bluish and greenish gray.	Brownish.
Slower setting than Rosendale.	Sets quickly in air. Hardens slowly in water.
Spec. Gr. 3.0. ±	Spec. Gr. 2.7.
Weight, 86 lb. per cu. ft.	Weight, 50 lb. ±per cu. ft.
Stronger than Rosendale.	Not as strong as Portland.

In the manufacture of Portland cement lime rock and cement rock are quarried separately, ground and mixed and then burned to incipient vitrification. The clinker is then crushed and pulverized and bagged for the market.

Rosendale cements are manufactured in a similar manner, only that the raw material is a natural mixture of the lime and cement rock.

28. How do you test cements?

Cements are tested to determine their

1. Fineness.
2. Setting.
3. Soundness.
4. Specific gravity.
5. Strength.

1. Fineness is determined by passing the cement through sieves of various meshes and noting the percentages retained.

2. Setting is determined by making pats of the cement and noting the time before they resist penetration of wires of specified weight.

3. Soundness is tested by noting the condition of the edges of the pats; also by heating pats with steam and seeing if they blow or crack.

4. Specific gravity is determined by apparatus provided for the purpose.

5. Strength is determined by preparing briquettes and permitting them to remain in air and under water specified periods, and then breaking them in a testing machine and noting the breaking load.

29. What are the important details of mixing and laying concrete to secure good work? (This does not refer to proportions of materials.)

Mixing boxes should be provided for the sand, cement and stone. The sand and stone must be clean and free from dust. The sand and cement should be thoroughly mixed dry, the proper amount of water added, and then the stone incorporated in the mortar.

The material should be deposited immediately after mixing in 8 or 12-in. layers and well rammed.

The forms should be firm, unyielding, smooth on the inside, and have tight joints.

The forms should be allowed to remain for 12 hours after laying.

Mortar or concrete partially set should not be tempered or used.

Work should not be done in freezing weather, and in warm weather concrete should be kept moist and protected from sun. When

new work is to be laid on old work, the old work should be thoroughly cleaned and painted with neat cement.

The work should be protected from traffic until thoroughly set. All exposed surfaces should be neatly pointed.

30. Give (*a*) full description of operation of mixing concrete by hand. (*b*) Describe any mechanical mixer with which you are familiar.

(*a*) See Question No. 29.

(*b*) For descriptions of mechanical mixers see trade catalogues, which can be obtained from manufacturers.

31. What are the objections to tempering concrete? (*a*) Why are masses of concrete left wet for several days? (*b*) Why do you mix broken stone and gravel wet? (*c*) Why do you not use the shovel in laying concrete? (*d*) When is concrete cheaper than brick?

Tempering concrete weakens it greatly. The concrete has already partially set and tempering disturbs the chemical action which has begun, reducing the tensile strength.

(*a*) Evaporation, percolation, and absorption by the stones cause a large loss of water in the mass of concrete and thus deprives it of the necessary water required for proper setting. In order to avoid this, the mass of concrete is kept wet.

(*b*) Broken stone and gravel are mixed wet, as they absorb water from the mortar and would therefore retard and interfere with its setting.

(*c*) If a shovel is used in laying concrete the mortar sticks to the shovel and will thus be separated from the stone; the water will run off the shovel, carrying the lightest material with it. This will be the case especially where the fall is considerable.

(*d*) Concrete is cheaper than brick when used in large masses and where expensive and elaborate forms are not required.

32. (*a*) How would you unite a new layer of concrete with old? (*b*) What is gained by storing Portland cement before using it?

(*a*) By thoroughly washing and scrubbing the surface of the old concrete and painting the surface with neat cement or a rich mortar before the new concrete is laid. It is claimed by some that the use of tempered concrete at junction of old and new work will give good results.

(*b*) Fresh cement contains free lime which causes expansion or "blowing" and might endanger the structure in which it is used in this condition. During the time of storing the free lime is changed to carbonate of lime and in this state the cement does not swell.

33. Describe briefly rubble masonry, ashlar masonry, and state the classes of engineering structures for which these, and also brick masonry and concrete, are each adapted.

Rubble masonry is composed of rough, undressed stone; it may be coursed, uncoursed or cobweb; used for cheap retaining walls, foundations of buildings, piers and abutments of highway bridges, and the backing of walls, dams, etc.

Ashlar masonry is composed of cut stone, either coursed or random, laid in close joints. It is used for first-class retaining walls, piers of railroad and highway bridges, and facework of dams, abutments, anchorages, arches, etc.

Brick masonry is used largely for walls and piers of buildings, for column footings, for sewers, arches of small span, etc.

Concrete masonry is adapted for all classes of engineering structures; especially adapted for underwater structures, such as pier foundations, etc.

34. State briefly what you know of concrete-steel construction and its advantages.

Concrete steel construction consists of steel imbedded in concrete so that the structure may act as a unit in resisting any strains that may come upon it. The steel is designed to take all the tension and the concrete the compression. Its application is universal, being used for the abutments and piers of bridges, arches, foundations, buildings, etc. Advantages: It is economical, durable, its elements easily transported, and it can be adapted to a variety of conditions.

35. How many barrels of cement, yards of sand, and tons of broken stone are required to make 10 yd. of concrete of proportions 1, 3 and 5?

Assume voids in cement = 0.
" " sand = 30%
" " stone = 40%

1 batch of concrete, proportions 1, 3, 5, will contain
1 bbl. = 3.7 cu. ft. cement
3 " = 11.1 " " sand
5 " = 18.5 " " stone

3.7 cu. ft. cement,	with	0%	voids,	gives	3.70	cu. ft. in concrete.
11.1 " " sand,	"	30%	"	"	7.77	" " " "
18.5 " " stone,	"	40%	"	"	11.10	" " " "
Each batch contains............					22.57	" " " "

For 10 cu. yd. of concrete there will be required $\frac{10 \times 27}{22.57} = \frac{270}{22.57}$ = 11.9 batches, say 12 batches.

There will be required, therefore,

$$3.7 \times 12 = 12 \text{ bbl. cement}$$

$$\frac{11.1 \times 12}{27} = 4.93 \text{ cu. yd. sand}$$

$$18.5 \times 12 = 222 \text{ cu. ft. stone} = \text{about } 22\,200 \text{ lb.} = 11 \text{ tons} \pm$$

36. What are the requirements for substantial stone masonry?

Substantial stone masonry must fulfill the following requirements:

The stone should be hard, sound, durable, cleaned and wet before laying.

The cement must be of A1 quality.

The sand must be clean, sharp, and free from loam.

In mixing the mortar care should be taken that it is done thoroughly, not in freezing weather; that the proper amount of water is used. In laying the masonry, all joints should be full of mortar, as few spawls as possible to be used. Courses should be well bonded. Stones must be properly bedded on natural beds. Joints must not exceed limits prescribed. All exposed face joints should be well pointed.

37. Give precautions in laying bricks where great strength is required.

The bricks should be thoroughly wetted just before laying. Every brick must be completely imbedded on mortar under its bottom, on its sides and on its ends at one operation. Every joint must be full of mortar. The joints must be close, not exceeding $\frac{1}{4}$ in., and pointed. Unfinished work must be racked or toothed. Before new work is added, the old work must be cleaned thoroughly and well moistened. The work should be well bonded.

38. Describe a quick, rough test for cement that can be made on the work without machine.

Make a small pat of neat cement and note interval of time elapsed until it resists slight pressure of thumb nail. Also note, after the cement is set, if the edges of the pat show cracks.

A ball 1 in. in diameter of neat cement is often made (by mixing with a little water) and allowed to set. It should not crack or crumble, but grow steadily harder.

39. Describe the requirements of good work in building a brick sewer.

The bricks shall be best quality, hard burned, free from cracks, and have true, even faces.

They must be thoroughly wet before laying.

Each brick must be laid in full mortar joints on bottom, sides and ends, which must be performed in one operation for each joint.

No mortar to be worked in after brick is laid.

Joints not more than $\frac{3}{8}$ in. in thickness.

Brickwork should be properly bonded and arches keyed.

Hydraulic cement should be used.

Cement and sand should be of proper quality and properly mixed.

The mortar should be used right after mixing; no mortar which has begun to set should be used.

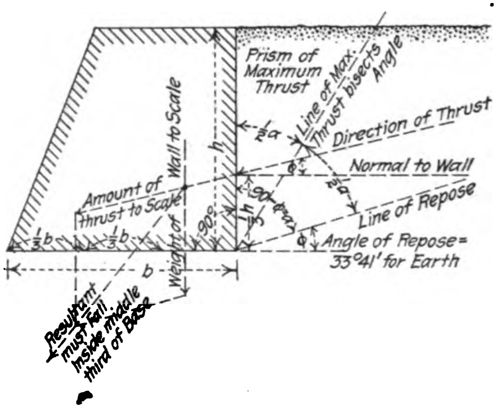
No work should be done in freezing weather.

Every second course should be laid with a line.

The foundation must be firm and unyielding.

Centers must be of proper form and dimensions, and proper care observed in "striking" same.

40. (*a*) Sketch a retaining wall showing the angle of repose of earth. (*b*) Show the line bounding the prism of maximum pressure. (*c*) Show the relation of the vertical angles bounded by these two lines. (*d*) Draw the diagram of forces acting upon the wall and show the position the resultant must take in order to insure stability.



41. In what way do retaining walls fail and why?

1. By overturning about the toe, owing to the insufficient thickness of the base of the wall.

2. By bulging or sliding due to the *excess* of the horizontal thrust produced by the backing, over the frictional resistance of the joints.

3. By crushing of the masonry due to its poor quality, to excess of unit pressure, or both.

4. By disintegration of the wall, caused by soft, yielding foundations, heaving and unequal settlement, or improper drainage of the backing.

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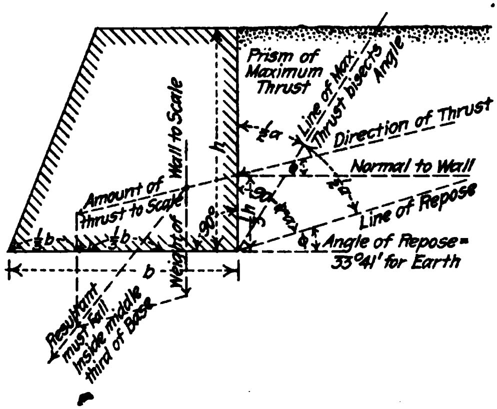

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42. What condition of failure of a rectangular wall is shown by (*a*) vertical cracks, (*b*) forward movement as a mass, (*c*) horizontal cracks and bulging. What remedies would you use in each case?

(*a*) Shows unequal settlement, remedied by increasing thickness of wall.

(*b*) Due to sliding of wall on its foundation; remedied by using land ties or building buttresses on the front face of the wall, also by shoring up the wall.

(*c*) Occurs in thin walls where the insufficient weight of masonry above a joint permits sliding. In this case the horizontal component of thrust against the wall is greater than the frictional resistances of the joint surface; remedied by increasing the thickness of wall.

43. If the backing of a retaining wall is very wet mud, how would you investigate the stability, not considering sliding?

In this case use the weight of the wet mud instead of dry earth and the corresponding friction angle in the calculations; or the wet mud may be considered as exerting purely hydrostatic pressure with thrust normal to the back of the wall.

44. Suppose the earth behind the wall is liable to be very wet at times, may any method be employed to reduce danger to the wall?

Yes. Weep holes should be left at intervals in the wall to carry off the water. Drains built along the wall and having a proper outlet will accomplish the same purpose. The backing adjacent to the wall should be of loose material, such as broken stone or gravel.

45. How would you provide for expansion and contraction in a long concrete retaining wall?

At intervals of 50 ft. or more openings are left about ½ in. wide, running the entire depth of wall, this space being filled with sand, asphalt or paper to retain backing. Steel rods may be imbedded to reduce effect of temperature changes.

46. Upon what does bearing power of piles depend and what precautions should be used in driving piles, and how would you find safe bearing power theoretically?

The bearing power of piles depends upon the skin friction or surface friction of pile and the point resistance; the former varying with size of pile and character of the material; the latter varying with the resistant character of stratum upon which pile rests. In driving piles, care should be taken to prevent "brooming" of head. A hoop or cap of iron may be used for this purpose. Excessive ham-

mering on pile that refuses to move should be avoided. Piles should be driven straight and to proper depth, with a proper fall of ram or hammer. Safe bearing power in pounds

$= \dfrac{2\ w\ h}{s + 1}$ in which

w = weight of hammer in pounds.
h = fall in feet.
s = penetration of last blow in inches.
This gives safety factor of 6.

47. How would you tell when a pile has been driven sufficiently?

When a number of successive blows produces a penetration equal to or less than amount prescribed by specifications. The load on the pile being known, the penetration may be calculated from formula. See Question 46. Test loads may be applied.

48. What effect, if any, has the brooming of a pile upon the effect of the hammer in driving it?

A "broomed" head acts as a cushion and dissipates the blow of the hammer.

49. Outline briefly the essential points to be covered in specifications for timber piles and pile driving.

The specifications should describe the kind of timber, such as oak, pine, etc. The pile shall not be less than 8 in. nor more than 12 in. at small end, and not less than 12 in. at large end. The timber shall be free from shakes and defects. The piles shall be pointed before driving. They shall be straight, and bark removed. Only portions left in work will be paid for. The top shall be banded before driving. The broomed portions shall be cut off. Iron shoes must be provided if necessary. The weight and fall of hammer and the penetration of the last blows shall be specified.

50. Describe the distinctive characteristics of foundations best adapted to the following sub-soil conditions:

(*a*) Stiff gravel.
(*b*) Wet, soft mud becoming stiffer as depth increases.
(*c*) Soft mud with hard gravel 15 ft. beneath.
(*d*) Wet but confined and compact sand.

(*a*) Excavate to the required depth; smooth the bottom and spread a layer of concrete over the foundation.

(*b*) Drive piles to proper bearing, cut the piles off level, build a timber grillage platform and place concrete on it, or cap the piles and surround with concrete.

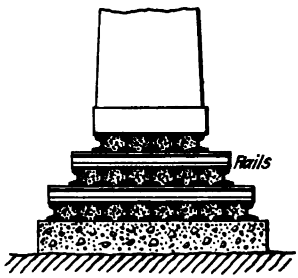
(*c*) Build a coffer-dam or sheath the outside of foundation; ex-

cavate the gravel, prepare bottom and deposit concrete, or proceed as in case of soft mud (*b*).

(*d*) Deposit concrete on the prepared bed of sand, confining sand.

51. What are the advantages of a grillage of layers of steel rails set at right angles in concrete, for a footing of a retaining wall? Show design for such a footing.

The grillage causes a uniform distribution of the load over the foundation, thus reducing the unit loads to safe limits.



52. How would you construct an earthen dam on gravelly soil so as to insure tightness?

Excavate to proper depth specified. Clean the bottom of all perishable material. If springs are encountered lead them off or tap them. Drive several rows of tongued and grooved sheet piling for cut off of water. Construct the center portion of puddle, the up-stream portion of fine material and the down-stream of coarse material, bonding the three portions well together. The up-stream slope about 2 to 1 and the down-stream about 2½ to 1. Pave the upper slope and sod the lower. Material should be deposited in layers, watered and rolled.

The necessary provisions for intakes, gates, overflows, etc., should be made.

53. Give method of obtaining size of whaling pieces and size and distance apart of struts.

The pressure or thrust on a whaling piece depends:

1. Upon its depth from the surface.
2. Upon distance between centers of whaling pieces.
3. Upon distance between centers of struts.
4. Upon the character of retained material.

The whaling pieces are considered beams uniformly loaded, whose spans equal the distances between centers of horizontal struts, each whaling piece supporting the earth half way to the next whalings above and below. The unit pressure at the depth of the center of

whaling piece times the supported area gives the load, and the size is computed by the beam formula.

When the size of the whaling pieces becomes too large the span is reduced by placing the struts nearer together. The size of the struts is obtained by the column formula, the load being that on half of each adjoining whaling piece, and the length, the width of the trench.

54. (*a*) How do circular arches generally fail; (*b*) segmental arches; (*c*) flat arches or 2 or 5-center arches?

The failure of most arches is due to unequal settlement.

(*a*) If the rise is less than the span the arch generally fails by the spreading of the haunches and the sinking of the crown. If the rise is more than the span, the haunches will generally be pressed inward and the crown will rise.

(*b* and *c*) For flat, segmental, or 2 and 5 centered arches, failure occurs usually by spreading of the haunches and sinking of the crown.

55. Define line of thrust, and in designing an arch where should it fall?

Line of thrust is the line of the resultant pressure due to dead and live load on arch. In designing an arch this line should fall within middle third of any joint.

56. How would you design the base of abutment of arch?

$$\frac{\text{The radius of arch in feet}}{5} + \frac{\text{rise in feet}}{5} + 2 \text{ feet}$$

$$= \text{with of abutment in feet (at springing line).}$$

The base is obtained by adding to this the additional width due to the batter.

57. (*a*) Describe the method of tunneling by shield, (*b*) by blasting.

(*a*) Shafts are driven at suitable points as at shore ends of a river, of sufficient size to permit lowering of shield, or the shield is erected in temporarily enlarged section of tunnel. A compressed air plant furnishes the air supply at required pressure to prosecute the work. Hydraulic jacks or rams force the shield ahead, the material filling the compartments of the shield being excavated by the men in same, through the bulkhead doors in shield diaphragm, and removed in cars to the shaft and out. The jacks bear against the finished lining of tunnel, which is carried ahead as shield progresses.

(*b*) See Question No. 58.

58. Describe the operation of tunneling for the work through rock.

After the shaft has been sunk to sub-grade, a heading, about 6 ft. square, is driven near the crown of the arch of the tunnel section. The drill holes are driven about 9 ft. in, and converging, so that the blast will remove a conical-shaped mass of rock. The sides are then taken out to the lines of the tunnel section. Following this, holes are drilled in the shelf or bench thus formed, the heading meanwhile being carried forward. Care should be taken in blasting that sides and roofs outside of tunnel lines are not disturbed, and that adjoining property is not endangered. Loose or disintegrated rock outside of tunnel lines should be removed. After each blast the rock or spoil is removed to the surface. Water-bearing seams should be drained or grouted.

59. After a blast has been made in tunneling, how would you examine the roof to see whether the rock was safe or so shattered as to be in danger of falling?

The roof, after being carefully inspected, is sounded or tapped with a long pole or rod, loose rock being readily located by the sound. Precaution must be taken in sounding against the danger of falling rock, the examiner standing to one side.

60. What methods and precautions are necessary in excavating rock, including blasting and all details in vicinity of houses, and what, when water pipes are present?

The contractor should comply with all ordinances of the city. Before a blast is fired the rock should be covered with mats and logs. The prescribed explosives should be used in small charges.

In residential districts blasts should not be fired between 8 P. M. and 7 A. M. No more explosives than is needed for 12 hours should be stored at one time on the work. It should be divided as much as possible and kept under lock and key, and separated from caps and exploders. Near water pipes rock within 5 ft. should be removed by hand.

61. Give precautions to be taken for the health of assistants or laborers working under pneumatic pressure at a depth of 75 ft.

Proper ventilation should be maintained. Carbonic acid gas not to exceed one-tenth of 1%. Noise-deadening devices should be used. Fumes from blasts must be rapidly removed. Ample locks of approved pattern must be provided. Suitable quarters should be provided near the shaft where men can wash, bathe, change clothing, be warmed on coming out of compressed air. Hot coffee should be obtainable at all times and physician must be in attendance. A compressed air hospital lock should be provided in case men are attacked by caisson disease.

62. What is meant by "cut and cover" method in open cut construction and what is gained by it?

The "cut and cover" method consists of excavating part or the whole tunnel section, building the side walls and covering the tunnel as soon as possible. It is used in city streets where the depth is not great enough to warrant tunneling. The object is to prevent as much as possible interference with traffic.

63. What is meant by (*a*) cut and cover, (*b*) ashlar, (*c*) three-centered arch, (*d*) sump?

(*a*) See Question No. 62.
(*b*) Ashlar refers to masonry composed of cut stones or blocks and laid in close joints.
(*c*) A three-centered arch is an arch composed of three arcs having three different centers, but only two different radii.
(*d*) A sump is a depression or well in low point of excavation into which all drainage is led and from which it is pumped.

64. What is done with water in a tunnel below the level of a sewer?

The water is drained into sumps at convenient points, such as stations, and discharged by automatic ejectors or pumps into the sewers.

65. In back-filling a trench, what is the arrangement of shovelers and rammers so that there shall be no subsequent settlement?

There should be three or four rammers to each shoveler, the ramming proceeding at the same time with the shoveling. The material is back-filled in layers and flushed.

66. When a trench for a wall has been made to the right depth in any kind of earth, what is the next step?

In earth objectionable material should be removed and replaced with good, firm earth. The bottom of the trench is then leveled off to an even surface, flushed and rammed. The footing courses are then laid. In rock the bottom is cleaned, stripped of disintegrated portions and stepped off. The masonry is then started.

67. (*a*) When is sheet piling left in? (*b*) When is it tongued and grooved?

(*a*) When careful drawing of same is apt to disturb retained material and thus endanger the foundations of adjacent structures.

Also when the cost of drawing same is greater than the value of the timber.

(*b*) Sheeting is tongued and grooved when driven in water-bearing material to keep water out or freely-flowing sand, mud, etc. It is tongued and grooved for coffer-dams, caissons, etc., to make water-tight compartments.

68. Under what conditions as to nearness of excavation, depth, character of soil, etc., would you consider it necessary to underpin buildings on the line of the subway?

Generally speaking, buildings whose foundation walls are above grade of tunnel and within 10 ft. of excavation require underpinning if the soil adjacent to excavation is of yielding or mobile character and cannot safely be supported by sheeting.

69. When water is being pumped from the soil in the excavation, how would you determine whether it is endangering surrounding buildings?

Examine the water discharged by the pumps, noting whether it is clear or contains material underlying the building foundations adjacent to the excavation. If the water is continually charged with this material, the foundations may be endangered.

70. Give essential features of the process of underpinning a large building and every precaution to be taken.

The essential features are:

1. The preparation of a firm foundation bed at or below sub-grade of excavation, to which the load carried by the piers or columns is transmitted.

2. The erection of footing courses and columns on these foundation beds, as in the case of permanent structures.

3. The setting of beams or cantilevers on these supports and wedging them under structure to be supported to prevent settlement.

The precautions to be observed are:

1. In excavating for foundations, etc., shafts and trenches should be dug as small as possible and far enough from building foundation not to endanger it.

2. The operation of wedging should be done with great care, so as to prevent undue strains.

71. Suppose a sewer crosses the work and has to be replaced by three smaller ones to make room for the work; is it sufficient to simply make them of a total equivalent section, or what else must be considered? State fully.

No.

The *discharging capacity* of the three small sewers must be equal to that of the sewer to be replaced. Since the wetted perimeter and consequently the friction of the three sewers is greater than that of the larger sewer, the velocity and therefore the discharge will be diminished. To obtain the same discharge, three sewers must be selected whose combined area is large enough to compensate for the loss due to increased friction.

72. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

The sewer is built along the new alignment, and when ready to join on to the old work a bulkhead of brick or cement bags is built at the points where the change of alignment begins and ends, the arch between the points having been removed. A temporary flume (or flumes) of sufficient size to carry the maximum flow, with the ends built into the bulkheads, is suspended or supported in the line of the old sewer, and far enough above the invert to permit the construction of the new invert at the points of connection. The old invert is now removed and the new work built and the connections made, when the bulkhead and flume are removed and the flow turned into the new sewer.

73. Describe briefly the operation of supporting and moving a large water main so as not to interfere with its use.

Block up the pipe on skids, long enough to permit lateral motion and having solid bearing. The skids are lubricated so as to facilitate the motion of the blocks on them. The lead joints being somewhat flexible and the spigots being set in far enough, slight motion is possible without causing leakage. Jacks are placed at the side of the pipe bearing against the trench walls or other solid support. Each length of pipe is now moved laterally a small amount, and the operation repeated until the required change is effected.

74. How is condensation prevented on station walls and roofs?

Condensation is prevented by providing a 1-in. air space between the station walls and roof and the concrete side walls, this air space extending from the ceiling to within a foot of the platform and communicating by vents with the outer air. The air space between the ceiling and roof jack arches prevents condensation on roof.

75. Describe how the standard railway track is best maintained in line and grade.

The rails are securely spiked to the ties set 1½-ft. centers, the latter being provided with tie plates.

Tie rods between rails at intervals of 10 to 15 ft. are used to maintain gauge. Good trap rock ballast is placed on the concrete floor and thoroughly wedged under and between the ties and around the ends to maintain the grade and line.

76. If a brick sewer is to be replaced by a number of cast-iron pipes so as to pass under the subway, how would you calculate the number and size of these iron pipes?

First ascertain the discharge of the brick sewer. Then decide tentatively on the number of iron pipes to be used.

Each pipe is to carry its proportion of the flow.

The length of each pipe is fixed by the width of the tunnel.

Then by the ordinary formulas for the flow of water in pipes the diameters are obtained. If these diameters are not convenient a different number of pipes is assumed and diameters recalculated, and so on until the proper number and size are obtained.

77. Describe damp-proofing and its methods of application.

"Damp-proofing" consists of a continuous sheet of asphalt and felt embedded within the concrete of the top, sides and bottom of the tunnel, completely enveloping it.

On the prepared surface of the concrete floor, side or roof of the tunnel a layer of hot asphalt is spread; on this a layer of felt is immediately rolled out while the asphalt is hot and made to stick over the entire surface; the joints in the felt should be broken. Care must be taken that the ends of the rolls of the bottom layer are carried up on inside of the layers on the sides and those of roof on outside with about a 3-ft. lap. On this layer of felt successive layers of asphalt and felt are laid in the same manner, two to six layers being used, according to nature of the ground. One or more courses of brick dipped in hot asphalt may be used in place of the above.

78. Outline specification for back-filling subway near adjacent sewer.

Filling should consist of sand, gravel or good clean earth free from stones over 8 in. in diameter and not containing more than one portion of stone to three of earth. It should be deposited in layers no more than 9 in. thick, watered and packed by rammers weighing not less than 30 lb., and in such manner that no unbalanced pressure can be thrown upon subway or sewer. Filling must be carefully packed and rammed about sewer, using special tools. No filling should be made with frozen earth. Sheeting should be carefully withdrawn as fast as filling progresses or may be left in place.

79. What do the specifications call for in regards to the storing of cement?

Cements should be stored in a tight building protected from the weather. The packages should be placed on a floor or platform raised several inches above ground. When stored out of doors canvas should be placed around them. Ample storage room should be provided so that lots can be separated for identification.

80. How would you store materials as to public safety and convenience?

Materials must not be piled within 4 ft. of any fire hydrant or fire alarm box. The Fire Department must be given access at all times and in all places to all buildings for extinguishing fires.

All material should be watered if stored temporarily in street, if so ordered. Paving stones, flagging, etc., if to be reused, shall be moved at once to another block or neatly piled along route, so as not to obstruct use of walks and street by pedestrians and vehicles.

81. How would you arrange the reports of your inspectors or other subordinates so as to obtain correctly the actual cost of any portion of the work?

Classify the work under proper headings.

Tabulate under each heading the forces employed and the material used.

Apply the prevailing rate of wages and the market price of material to compute the cost of each class of work.

To the cost thus computed add an allowance of about 15% for superintendence and also an allowance for interest and depreciation of plant to arrive at the total cost.

The unit cost of any class of work can then be found by dividing the total cost of that class by the number of units completed.

82. How would you inspect a job of riveting?

With a special hammer weighing about a pound, blows are struck sharply on each side of the head of the rivet.

Loose rivets will be indicated by jar or rattle.

Also examine edges of rivet head, observing that there are no marks of caulking tool. See that the heads are concentric, fit closely all around and are free from cracks, and that no impress on the metal around the head has been made in driving the rivet.

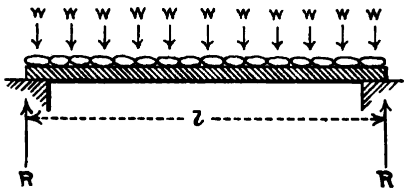
The rivet heads should be full size.

83. In inspecting (*a*) a piece of finished riveted work, what defects would you look for in the riveting, (*b*) in a heavy casting as a base of a column?

(*a*) See Question No. 82.

(*b*) In inspecting castings look for honeycomb. Blow holes or sand holes when filled with sand or loam are detected by a dullness in sound, upon tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges. Warped castings or those that are incorrect in dimensions should be rejected.

84. Make a sketch of a beam uniformly loaded. Show reaction at each support in terms of $w\,l$, etc., and moment at center.



w = weight per unit, l = length of span, R = reaction at support.

$$R = \frac{w\,l}{2}$$

$$\text{Moment at center} = R \times \frac{l}{2} - \frac{w\,l}{2} \times \frac{l}{4} = \frac{w\,l}{2} \times \frac{l}{2} - \frac{w\,l^2}{8} = \frac{w\,l^2}{8}$$

85. Describe the method of transmission of electrical power by a third rail, stating briefly its advantages and disadvantages.

The third rail is divided into sections one-half mile or so in length, and receives its power from feeders passing through ducts along tunnel wall and under station platforms. These feeders or cables, proceeding from the power house or substations, are tapped at various intervals, supplying direct current at about 550-600-volt pressure to the third rail. Insulating blocks electrically separate the third rail from the track or subway floor, which acts as the return circuit. The advantages are cheapness, simplicity of construction, economy of space.

Disadvantages are danger in case of accident; its exposure and easy accessibility, endangering life.

86. Write a report on a job of pile driving for the abutments of a bridge and for getting in the footings of the same.

The report should include: (*a*) the character of the foundation, number and spacing of piles, their original lengths and diameters, the kind of timber, etc., depth to which they are driven, description of apparatus, weight and fall of ram, penetration of last blows, etc.

(*b*) The grade and amount of cut off, the net lengths remaining in, and the total lineal feet of piles to be paid for should be given. The number of piles delivered, used and rejected, the reasons for rejection, the number broken and pulled up should be tabulated.

(*c*) The formulas used and tests for the bearing power of piles.

(*d*) For getting in the footing courses the report should give depth and extent of excavation, depth of footing course and offsets, the proportion, character of ingredients, methods of mixing and laying the concrete, forms and amount of timber used.

(*e*) Force and material accounts.

87. Make a report and write specifications for materials and building of a 20-ft. semi-circular arch, assuming it to be 2 ft. thick.

They should include a detailed description of the site, of the character of the foundation for the side walls, giving results of borings and test pits, if any. It should also contain calculations and method of design of arch, giving loadings assumed, etc. Also estimate of quantities, of cost, time, and comparisons between costs of different materials. Specifications should cover the following items: Excavation, rock and earth; cement, sand and broken stone, if any; mortar, how mixed; masonry, the various classes in structure; method of laying, centering, timbering, etc.; character of spandril filling; method of striking of centers, etc.

88. At *Times* station why is there 1 ft. between platform and entrance to cars?

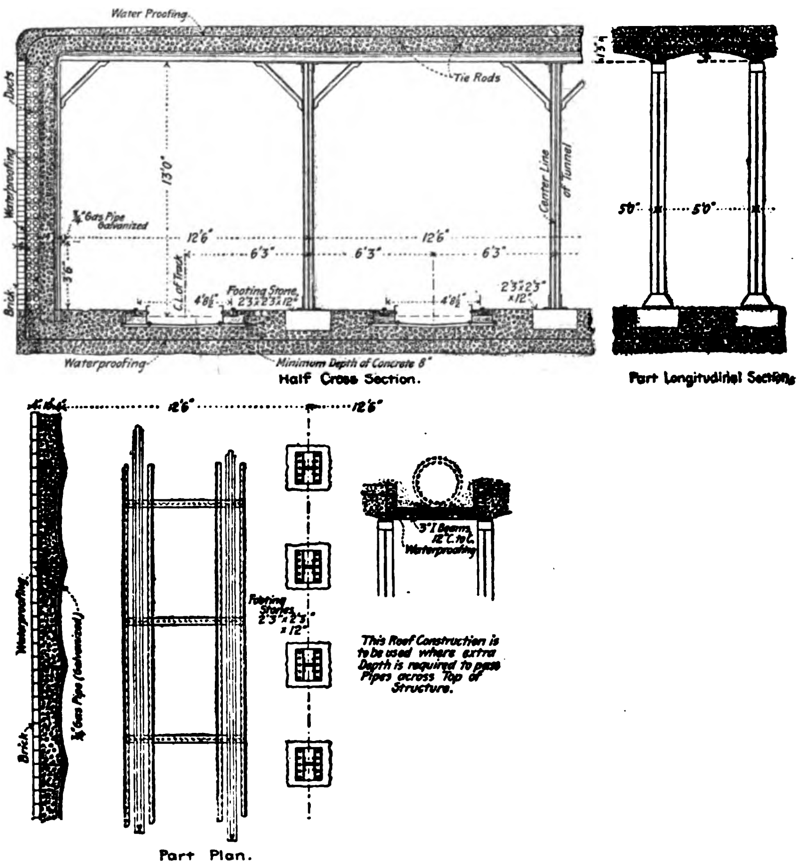
The edges of station platforms at Times Square are on curves parallel to the tracks. To permit cars of train to pass around same, the side of the car being parallel to a chord of the curve, a clearance of 1 ft. between platform and car entrances is required.

89. How would you figure the spacing for the iron bents of the subway when on a curve?

On the center line of the tunnel the iron bents should be spaced the same as on the tangents—5 ft. apart.

The inner and outer bents are on radial lines to the curve, so that the inner spacing will be less than and the outer spacing more than 5 ft., the distance being computed from the respective radii.

90. Show by sketch a typical vertical cross-section of a four (4) track tunnel where it is necessary to keep close to the surface, including important dimensions and indication of materials used.



Cross-Section of New York Subway.
(From Stauffer's "Modern Tunnel Practice," by permission.)

TYPICAL FORM FOR MONTHLY ESTIMATE.—90 PER CENT. PAYMENT

THE CITY OF NEW YORK. ESTIMATE No.........................

To.. ....Dr.

For work measured and estimated in constructing.................................., under a contract dated...from ....1. , to...................................1, .

Total Quantities Estimated to Date Including Present Estimates.	Total Quantities Previously Estimated.	Approximate Quantities Measured and Estimated for above Month.			Description of Work Done.	Unit Prices.	Monthly Amounts.		Total Amounts.	
							Dollars.	Cts.	Dollars.	Cts.
2 000	1 000	1 000	a	cubic yards	Removal of soil taken from spoil banks, including all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	aa	square yards	Sodding, including all work incidental thereto.	0.20	200	00	400	00
2 000	1 000	1 000	b	cubic yards	Earth excavation, including the disposal of it, and all work incidental thereto.	0.30	300	00	600	00
2 000	1 000	1 000	c	cubic yards	Rock excavation, including the disposal of it, and all work incidental thereto.	2.00	2 000	00	4 000	00
2 000	1 000	1 000	e	M. ft. B. M.	Permanent timber work, placed and fastened, including all work incidental thereto.	55.00	55	00	110	00
2 000	1 000	1 000	f	barrels	Portland Cement, in barrels of 400 pounds, ordered by the Engineer, and placed in the work, including all work incidental thereto.	2.50	2 500	00	5 000	00
2 000	1 000	1 000	g	cubic yards	Concrete masonry in place, formed of five parts of broken stone, or gravel, or a mixture of both, to one part of cement, and made with American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all work incidental thereto.	4.00	4 000	00	8 000	00
2 000	1 000	1 000	h	cubic yards	Brick masonry, not included in item (h h), laid in American Cement Mortar mixed in the proportion of one part of cement to two parts of sand, including all plastering and pointing, all scaffolding, centers, forms, etc., and removing the same, and all work incidental thereto.	9.00	9 000	00	18 000	00
2 000	1 000	1 000	i	cubic yards	Rubble stone masonry, laid in American Cement Mortar mixed in the proportion of one part cement to two parts of sand, including all work incidental thereto.	3.00	3 000	00	6 000	00
					Total amount estimated				$42 700	00
					Total amount previously estimated				21 355	00
					Total amount of present estimate				$21 355	00
					Total amount of work measured and estimated between the above dates		$21 355	00		
					Deduct 10 per cent		2 135	50		
					Balance due for work measured and estimated during the month		$19 219	50		

I hereby certify that this is a just estimate of the approximate amount of work measured and estimated between the............and........ days of..............................190.. both inclusive.

CHIEF ENGINEER,

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN 3 VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER
VOL. III. DRAFTSMAN, AND INSPECTOR

VOL. II. PART II.

ASSISTANT ENGINEER
GENERAL, AQUEDUCT, DOCKS, SEWERS & HIGHWAYS

INDEX

NEW YORK:
THE ENGINEERING NEWS PUBLISHING COMPANY
1906

PREFACE.

In the "Previous Examination Papers," which have been included in this book, the questions may not, in all cases, be identical in wording with those actually given at the examinations, as copies of the original papers are not readily procurable, but they do embody the substance of questions asked.

The papers marked "Miscellaneous Questions" are compiled from many sources, having their origin at examinations held previous to the dates given, and are inserted to enhance the value of the book.

In the section devoted to "Typical Questions and Answers," great care has been taken to make the answers conform with the best modern practice. Reasonable variance of opinion may exist as to what is the best answer, owing to differences in interpretation of the questions and in education and experience, but it is sufficient to say that the answers are based on such recognized authorities as Trautwine's "Civil Engineer's Pocket Book," Baker's "Masonry Construction," Byrne's "Highway Construction and Inspector's Pocket Book," Merriman's "Hydraulics," Fanning's "Water Supply," and Patton's "Civil Engineering."

In order to perpetuate the value of the book, blank leaves have been inserted after the "Previous Examination Papers," allowing for the convenient addition of new sets, and the "Typical Questions and Answers" have been interleaved to provide space for notes, sketches and additions.

PREVIOUS EXAMINATION PAPERS.

ASSISTANT ENGINEER—GENERAL.

Salary, $1 200 to $3 000 per annum.

MISCELLANEOUS QUESTIONS, COVERING A NUMBER OF ASSISTANT ENGINEERS' EXAMINATIONS.

October, 1891.

1. Show graphically the resultant of three or more forces acting in the same plane.

2. $V = \sqrt{2\ g\ h}$. What is the value of g? Give application.

3. What is a vernier?

4. What is your method of calculating earthwork?

5. What instruments are necessary in laying out a curve, and describe their uses?

6. What are the physical differences between American Portland and Rosendale cements? How are they manufactured?

7. How do you test cement?

8. Find the horse-power of a stream, discharge 100 cu. ft. per sec., fall 10 ft.

9. What practical method do you know of for measuring the discharge of running water in open channels?

10. Give formula for above, or state where it can be found.

11. In a rectangular dam where is the center of pressure?

12. Where should the line of pressure on an arch fall?

13. What is the law of liquids at rest?

14. How high can you pump water with a suction pump, at sea level?

15. At 7 000 ft. above sea level?

16. What do you mean by the grade line of a pipe, and its hydraulic grade line?

17. What relation should exist between them?

18. What is the wet perimeter of an egg-shaped sewer 3 ft. x 2 ft. running full?

19. What is the number of bricks in a running ft. of 8-in. work?

20. When would you prefer pipe and when brick sewers?

21. What is the horse-power necessary to lift 2 240 lb. 100 ft. per sec.?

22. What is the safe load for earth foundations?

23. What is the best method of preserving piles in sea-water?

24. Same in ground?

25. What is the weight of a cast-iron wedge 1 ft. x 2 in. x 3 in. high?

ASSISTANT ENGINEER—GENERAL.

MISCELLANEOUS QUESTIONS—BROOKLYN, Dec., 1894.

1. What is meant by the acceleration of gravity, and what is it in figures?

2. Through what distance does an ordinary body fall in the first second and third seconds; and what is its velocity at the end of each second, in feet?

3. Do these distances hold good at all points on the earth's surface? If not, where are they the least or most?

4. What is the fundamental law or equation upon which the flow of water in pipes, conduits, streams, etc., is based, and what modifications in it are necessary when it is applied to particular cases (if answered by equations explain the symbols)?

5. Given two reservoirs 500 ft. and 2 000 ft. sq., and filled with water 20 ft. deep, the banks being 25 ft. high, how much heavier or thicker should the wall or bank be in the one case than in the other, and why?

6. If, in running a line in an open level country, you find it passes through a house near to the bank of the stream which the line would cross, how would you pass the obstacle, triangulate through it and across the stream, get the distance and continue the line if you had no note books or tables but only your surveying instruments?

7. How would you proceed if your line ran east and the stream northwest and southeast and you had to do all your triangulation on the north side of your line?

8. What is the ordinary velocity of sound per sec., and does the velocity vary with the temperature or not? If so, how?

9. What is the boiling point of water at sea level, and how does it change as you rise above the sea? What change for 5 000 ft. rise?

10. What is the average rainfall in the vicinity of New York City and how much of it may usually be expected to flow down the streams? Answer in inches of rainfall. If not familiar with this locality, answer concerning the locality in which you have been through most of 1894.

11. Describe method of ascertaining the horse-power of a running stream, and give an illustration and example, including a

sketch of a weir in a stream. How much of the theoretical horsepower can be obtained in practice, and delivered to a line shaft in a mill?

12. Show by means of diagrams the sines, cosines, tangents, cotangents, versed sines and co-versed sines of one angle of about 40° and one of about 150°.

13. Describe method of making and laying concrete, stating what tests of cement should be made, how to select or secure good sand and stone, size of latter, the proportion of each with Rosendale or Portland cement, and the manipulation of materials so as to secure good results. What is meant by "voids" in engineering practice?

14. Suppose a double-track standard gauge railway, which now runs through a street, is to be lowered 25 ft. and made to run through a tunnel under the street, the surface of which then will be given up to ordinary street traffic. The entrance to the tunnel will be faced with stone and have wing walls at an angle with the track, the arch being rather flat. Sketch roughly the elevation of a suitable entrance, making it to a scale of ⅛ in. to 1 ft. and designate the different kinds of masonry, names of different parts and kind of material which should be used.

15. The above tunnel after passing the entrance will have side walls with vertical face and a brick arch. Sketch this section, and describe the parts from foundations to street surface: making sketch on scale ¼ in. to the foot (sketch need only show as much of the construction as can be put in a space 6 in. wide. It can be broken off on one side of center line).

16. What is meant by the terms "separate system" and "combined system" in sewers?

17. What is a catch basin, and what is its use? Sketch one and describe construction.

18. What is a manhole, and what is its use? Sketch one and describe construction.

19. What is a flush tank, and describe its uses?

20. Sketch an oval sewer, *i. e.*, egg-shaped, and give radii of all arcs in terms of greatest horizontal width.

21. What is the reason for the use of an oval sewer?

22. What is meant by hydraulic mean radius?

23. What is the proper maximum velocity of flow through sewers?

24. What is the minimum slope allowable for 6-in., 9-in., 12-in. and 24-in. sewers and the least allowable in any sewer?

25. For what rainfall per hour, reaching the sewers, should a sewer be designed for an area of 20 acres; also for 500 acres?

26. Having a rainfall of 2 in. per hour in a well-paved compactly built city, what size circular sewer having a fall of 2 ft. in 100 would be necessary to carry off the water from an area of 20 acres, assuming that all the rainfall reaches the sewer? Show calculation or describe it, if you would use tables such as you would expect to have in your office, state just what the tables are, where they would be found, and how you would use them.

27. Would the sewer run full or only partly full?

28. If left with you to decide, would you make this sewer a pipe sewer or an oval brick sewer?

29. Describe order of work in a street where you wish to lay a pipe sewer and be sure that each pipe is on exact grade.

30. What are the different kinds of road or street surfaces in use in American cities, and in what order of merit would you arrange them? Begin with common dirt road.

31. What are "curb" stones and "bridging" in street work? Of what material should they be, and of what dimensions? To what extent should they be dressed?

32. Describe the steps of construction of a first-class pavement and street to take the place of a common dirt road.

33. Sketch the finished work. Suppose roadway to be 40 ft. wide and two sidewalks each 10 ft. wide. Note various measurements.

34. How is the best granite block pavement constructed, and what would such work as you describe cost per square yard?

35. How is the best asphalt pavement constructed?

36. Where are the principal asphalt deposits found? What is the difference between "land asphalt" and "lake asphalt" from Trinidad, chemically?

37. Is an asphalt pavement injured by water standing upon it and, if so, how does it deteriorate?

38. To what tests would you subject a brick to determine whether or not it was suitable for use in street pavements?

39. Describe the construction of a first-class brick pavement, giving sketch and dimensions of brick and of the different parts of the pavement from curb to curb.

40. What are the advantages and disadvantages of different kinds of pavements?

41. What are current prices of pavements in the vicinity of New York?

42. What is a maximum safe load, in pounds per square foot, to place upon good dry sand or good earth in constructing foundations?

43. Sketch a timber crib suitable for a bridge pier and describe it.

44. Sketch a pneumatic caisson for bridge pier.

45. Sketch a coffer-dam for bridge pier.

46. Sketch a Howe truss, and name different members.

47. Explain the terms "positive" and "negative" in electricity and state what is meant when a water main is said to be "negative" to a rail in a track above it.

48. To prevent or reduce electrolysis of water pipes should the pipes be positive or negative to the rail and why?

49. What is meant by the term "duty" as applied to pumping engines?

50. If a metal has a breaking strength of 1 000 000 lb. per sq. in. in tension, how thick should a 12-in. pipe (inside diameter) be, to safely conduct water from a reservoir which has a water surface 200 ft. above the point of delivery? Show the calculation.

ASSISTANT ENGINEER--GENERAL.

MISCELLANEOUS QUESTIONS—NEW YORK, 1896.

1. What is your experience in civil engineering?

2. Have you ever pursued a course of study in any institution or with any civil engineer, which fits you for the position of assistant engineer?

3. Have you ever had any responsible charge of any public work? State particulars.

4. Solve the following according to the algebraic signs and show work.

5. The population of a certain town, in 1880, was 7 095; it having increased 25% in 10 years, what was it in 1870? Show your work.

6. How many feet board measure in the flooring of a room 20 ft. by 30 ft. and $2\frac{1}{2}$ in. thick?

7. Find the value of x and y in the following equations:

$$2x + 3y = 33,$$
$$4x - y = 17.$$

8. Find the value of x in equation: $x^2 - x - 40 = 170$.

9. Find the value of x in equation: $x^2 + x + 40 = 100$.

10. Explain the meaning of the expression $(a + x)^{\frac{3}{2}}$.

11. What is a logarithm?

12. What is the base of the common system?

13. In making what calculations are logarithms useful?

14. How do you find the logarithm of a number in the table of logarithms?

15. What are similar triangles?

16. How are similar triangles proportioned to each other?

17. The sides of a polygon being prolonged, what is the sum of all the exterior angles equal to?

18. How do you pass the circumference of a circle through three given points not in the same straight line?

19. How do you describe a square in a circle?

20. Make a sketch of the form of cast-iron beam best adapted to resist a transverse strain.

21. How do you describe a regular hexagon in a circle?

22. What proportion do circumferences and areas of circles bear to their radii?

23. How do you find the area of a regular polygon?

24. How do you find the area of an irregular polygon?

25. How do you find the area of a circle?

26. How do you find the solid contents of a cylinder?

27. How do you find the solid contents of a wedge?

28. How do you find the solid contents of a pyramid?

29. Find the contents of the wedge, base 20 ft. x 30 ft., height 10 ft., edge 15 ft.

30. State the prismoidal formula; would you use it in calculating earthwork?

31. Calculate the following sections, cutting being denoted by plus, filling by minus; both being written over the distance from the center, slopes 1 to 1.

32. How many and what parts of a plane triangle must be given to find the rest?

33. Define the terms sine, cosine, tangent and co-tangent.

34. What are natural sines, cosines, etc.?

35. What is a table of logarithmic sines, cosines, etc.?

36. Two sides and two angles of a plane triangle being given, how do you find the other parts?

37. When two sides of a plane triangle and the included angle are given, how do you find the other parts?

38. In the right-angle triangle, express algebraically the value of the sine, cosine, tangent and co-tangent.

39. What is the law of gravitation?

40. Do you understand that there is any difference in the meaning of the terms of gravitation and gravity?

41. What is the law of falling bodies?

42. Express algebraically this law, calling v velocity of falling body; a acceleration of gravity; and h height.

43. What is the center of gravity of a body?

44. How is it found?

45. Where is the center of gravity of a homogeneous body whose sides are all rectangles?

46. What is the specific gravity of a body?

47. What is the standards for solids and liquids?

48. What for gases?

49. What laws govern the pressure of liquids at rest?

50. How do you find the number of gallons of water to the cubic foot?

51. What is the weight of a gallon of water?

52. What is the pressure per square inch on the side of a vessel at the depth of 10 ft. below the surface of the water?

53. What will be the theoretical volume of discharge per second from a reservoir through a pipe 1 ft. in diameter, discharging at a depth of 100 ft. below the surface of the water?

54. How many gallons of water will be discharged through a pipe 1 ft. in diameter, 328 ft. long, head 13½ ft. coefficient of flow pipe 1 ft. in diameter, 328 ft. long, head 13½ ft. coefficient of flow = .007?

55. State how many men are needed to make up a full party for a survey of a preliminary line or location of a public work, such as a railroad or aqueduct.

56. State also their several duties.

57. For what purpose is the magnetic needle used in surveying land?

58. What is a traverse table and what is it used for?

59. How do you set out a circular curved line upon the ground?

60. If an obstacle occurs to alignment, state how you would overcome it upon straight lines; also upon curves.

61. The radius of a curve being given and angle of intersection of two tangents, how do you find the length of the tangent from their intersection to the beginning of the curve?

62. Describe the engineer's transit, and name its adjustments.

63. Describe the Y level and name its adjustments.

64. How many kinds of leveling rods do you know of?

65. State how they are graduated, and how they can be read to thousandths of a foot.

66. Show a form of field book for transit notes used when "running curves," and place thereon notes of a 5°-curve for 1 000 ft., with two intermediate set ups.

67. Show a form of level-book, and place thereon sufficient figures to show your method.

68. What are cross-sections?

69. How do you set slope stakes for excavation and embankment?

70. What is a grade line?

71. What proportion of the breaking weight of a beam would you consider a safe load?

72. With the load uniformly distributed, what fractional part of the whole weight may be considered, in all calculations, as being carried at the center?

73. Suppose a beam supported at both ends, and take w = weight 1 = length of beam, b = breadth, d = depth, S = breaking weight, express algebraically the value of S in terms of the other quantities.

74. Sectional area being 36 sq. in., which would be the stronger section, 6 x 6 or 4 x 9?

75. Make a design for a pair of rafters, connected by a tie beam, for a roof 30 ft. span, showing the dimensions of the several parts and the manner of connecting them. State in detail your method of obtaining several dimensions.

76. How do you apply the principle of the parallelogram of forces in determining the strain on the various members of a structure; illustrate graphically.

77. What should be the thickness at the top and base of a retaining wall 15 ft. high, built to retain ordinary earth? Show your method of obtaining the required dimensions; also a sketch of the wall, showing how it should be founded.

78. A reservoir is to be built—depth of water 10 ft. If the walls are built of masonry, find the thickness of the same, and state how they should be built. Show your work.

79. What is an arch, of how many forms, and of what may it be constructed?

80. Can you state how you would find the thickness of an arch of stone, span and rise being given?

81. Define the intrados and extrados of an arch.

82. Where should the line of resistance to pressure be found in an arch in order to retain its stability?

83. How can you find the thickness of the abutments, the rise and span of the arch being given?

84. In the semi-circular arch, where is the horizontal thrust greatest and where least?

85. Name the common kinds of stone used in building.

86. Define the terms "quarry-faced," "rough-pointed," "fine-axed," "bush-hammered," as applied to the dressing of stone.

87. Describe "rubble" masonry, "ashlar" masonry, and "broken ashlar" masonry.

88. What are "headers" and stretchers?"

89. What should be the proportion of "headers" to "stretchers"?

90. How would you prepare the foundation of a heavy wall, and how deep should it be excavated?

91. How are walls founded on soft or yielding materials?

92. Describe a good quality of bricks, and state how you would know a good brick from a poor one.

93. In how many ways is brick work "bonded" to make good work in heavy walls?

94. What is hydraulic cement, and how many kinds do you know of?

95. Which do you consider the better cement, Rosendale or Portland, and why?

96. What is mortar composed of, and how mixed?

97. What kind of sand should be used, and how do you test its quality?

98. What is the meaning of the term "setting" as applied to cement?

99. How would you test cement?

100. What is concrete; of what composed, and in what proportion should its ingredients be mixed?

101. Name the common kinds of wood used in building.

102. What kind of timber resists decay longest underground?

103. How may timber be preserved from decay?

104. What do you understand by limit of elasticity as applied to a beam under strain or pressure; what is meant by the neutral axis of a beam?

105. What is the tensile strength of a good quality of wrought iron per square inch?

106. For what parts of a structure may cast and wrought iron be used in reference to tension and compression?

ASSISTANT ENGINEER—GENERAL.

NEW YORK, Feb. 23, 1897.

1. State the duties of an Assistant Engineer.

2. Write specifications for broken stone, sand and cement in first-class concrete, and give details of mixing and laying.

3. Write specifications for brick to be used in a large sewer, and give method for laying same.

4. Give sketch of a retaining wall 20 ft. high, to retain earth, and give dimensions.

5. If above wall is in massive blocks, write specifications for wall and exact way in which stone must be manipulated for best results.

6. Suppose the earth behind the wall is liable to be very wet at times, may any method be employed to reduce the danger to the wall?

7. A segmental arch has a rise of 5 ft. and a span of 40 ft., state approximately how much the horizontal thrust would be increased by an additional center load of 40 000 lb.

8. Define the line of thrust, and in designing an arch where should it fall?

9. How would you design the base of abutment of an arch?

10. Suppose abutment to be built on compressible ground, give sketch of foundation you would use, with dimensions, and give reasons for each step.

11. What is the safe load for a well-driven pile?

12. Give safe loads for clay, sand, gravel and loam.

13. Give weight of cast iron, wrought iron, water, moist sand, concrete, brickwork with close joints, and limestone masonry.

14. Write specifications for piles and method of driving.

15. Write specifications for 12-in. pipe sewer, in reference to quality, testing and delivery of pipe.

16. Write specifications for laying pipe sewer, including refilling in trenches.

17. Describe points to be observed in digging a trench where blasting is likely to occur, trench being near a water main.

18. Describe in detail the method of laying a 36-in. water main.

19. Write monthly estimate for regulating, grading and paving a street with stone blocks.

20. Give estimates for materials for a 4 ft. brick sewer 1 000 ft. long.

21. An important sewer is to run along a line, part through rock, part through unknown material and balance to outlet over salt marsh. Being directed to make an examination of the line, write your report stating everything done and give recommendations.

ASSISTANT ENGINEER—GENERAL.

New York, August 20th, 1897.

1. Draw diagram showing radius and length of a curve and tangent, and also tangent to both sides.

2. Sides of a triangle are 120, 60 and 70, find the area.

3. Give relation between sine, cosine and tangent.

4. How would you give grades for a sewer?

5. What are the conditions of the stability of a retaining wall?

6. Show graphically how to adjust an error of closure.

7. What precautions should be taken in building a retaining wall?

8. How would you lay out a simple curve?

9. To what points would you pay special attention to in laying a water pipe?

10. How would you determine what size of culvert to use?

11. How would you guard against a washout?

12. How would you make a survey to determine capacity of a reservoir?

13. How would you compute above capacity?

14. There is a load on the roof of 12 lb. per sq. ft., horizontal wind pressure 30 lbs. per sq. ft., rafters 3 ft. apart; find stresses in all members.

15. What is the center of pressure and find it on a rectangular gate immersed in water.

(Board of Public Improvements, Dept. Highways, Etc.)

1. State in detail what experience you have had in topographical work, drainage and highway construction, which would especially fit you for this class of work; giving place and kind of work.

2. (*a*) What use is made of the magnetic meridian in surveys? (*b*) State the sources of error in making a survey by the magnetic needle. (*c*) Are surveys usually made with magnetic needle?

3. (*a*) Name the different kinds of pavements in use in cities. (*b*) Give a brief description of each. (*c*) State the conditions under which each can be used.

4. (*a*) What is rubble masonry? (*b*) Ashlar masonry? (*c*) In what engineering structures is each used and when are brick masonry and concrete used?

5. Give the angle of intersection and P. C. of a street or railway curve, show how you would run out the curve.

6. Where a street or railway in embankment crosses a stagnant pond the bottom of which is soft material state what method you would pursue in making an earth-fill across the same to obtain a permanent embankment.

7. (*a*) Where a street crosses a valley by embankment sustained by a retaining wall of masonry, show how you would obtain the dimensions of the wall. (*b*) Explain the theory of pressure of earth against a retaining wall.

8. What is the least grade desirable in a street gutter and how would you arrange the grade in a street where the existing grade between two intersecting streets is too flat for proper drainage?

Promotion to Assistant Engineer, Borough of Richmond,

August 25th, 1902.

1. Describe the different kind of street pavements and show dimensions and construction.

2. What is the minimum allowable gutter grade for granite block pavement?

3. What is the minimum allowable grade for 6 in., 8 in. and 12 in. sewer pipe?

4. What is the maximum allowable grade for asphalt pavement?

5. What is the method for calculating areas from traverses?

6. Calculate the area of an egg-shaped sewer equal to 10 ft. circular and show construction in soft wet gravel.

7. What is the greatest allowable error in precise leveling for 4 miles?

8. What is a fair closure of 20 angles in a traverse?

9. Show design for retaining wall with earth slope of 45° from top—also show design for abutment of arch bridge at tide water.

10. Show method of calculating sizes of outfall of lateral sewers.

ASSISTANT ENGINEER—GENERAL.

TECHNICAL.

NEW YORK, OCTOBER 9, 1899.

1. (*a*) What do you understand by the "angle of repose" of earth? (*b*) At what point above the base of a retaining wall will the centre of pressure from earth behind it be located, when the earth is level with the wall?

2. (*a*) Within what limits of the base of a retaining wall or the abutments of an arched bridge, must the line of thrust fall to insure stability? (*b*) What proportions of headers to stretchers should be used in an abutment wall?

3. About what pressure per square foot can safely be placed on the following materials in founding structures upon them where liable to be continually wet; (*a*) stiff clay; (*b*) loam; (*c*) gravel? (*d*) In taking loamy earth from a "borrow pit" what difference in cubical contents will there be between the "borrow pit" and the complete "fill."

4. What is the difference between "refraction" and "reflection" as applied to light, and how does the former affect the line of sight taken through a level?

5. Suppose you had in leveling to take 1 600 feet sights; how can you do it with reasonable accuracy and eliminate the effects of "curvature" and "refraction"?

6. What are the several qualities of cast and wrought iron and wrought steel which make them useful for various classes of engineering construction? Describe briefly the work for which each is well adapted and in general the methods by which you would test them.

7. Outline briefly the essential points to be covered in specifications for timber piles and pile-driving.

8. Describe the various ways of shaping and using sheet piling to keep water from work in progress.

9. What is hydraulic cement, and what are its properties and uses as regards engineering construction? Outline briefly the methods by which you would test the relative merits of two or more samples.

10. Show a form for monthly estimate to a general contractor, including at least six items of material or labor on some kind of city engineering construction; assume quantities and set unit val-

ues agreeing approximately with present market values; carry out the arithmetic, show percentage returned and previous payments.

REPORT.

Write a report covering at least two pages on the location and design of some public work with which you are acquainted, giving the reasons why the design was adopted in the form given. Also give the progress of the work up to some given time, containing such items as a progress report to your chief ought to contain.

MATHEMATICS.

GIVE ALL THE WORK ON THE RULED SHEET.

1. If 12 men can shovel 90 yd. of earth in an hour and a half, how many men will be required to shovel 2 550 yd in a working day of 10 hr.?

2. A culvert must take drainage from 1 000 acres. How many cubic feet per second must be carried by the culvert?

Use formula $Q = c\,y\,\sqrt[4]{s\,a^3}$, where Q equals cubic feet per second reaching culvert; c equals proportion of rainfall reaching culvert; y equals rainfall per hour; s equals average slope of water shed in feet (per 1 000 ft. of horizontal distance) and a equals acres of water-shed. (Give values to c, y and s according to your judgment; exact quantities are not required.)

3. A grade of 1/270 is how much per 100? How much per mile?

4. A building is 50 ft. wide and the pitch of a peaked roof is 30°. What is the length of the rafter. With rafters spread 10 ft. apart what is the strain in the rafter from a uniform load of 30 lb. per square foot of horizontal area?

5. Extract the square root of 47 065.06.

EXPERIENCE.

1. Have you taken a regular course of instruction as an engineer in any college or technical school? If so, at what one? What was the length of the course, and what degree or diploma did you receive, if any?

2. If you have not taken such a course, state what your education as an engineer has been.

3. Have you followed any mechanical pursuit, and if so, what, and how long.

4. State what experience you have had in the practice of engineering, particularly in City work.

5. If there are any other points you consider important in your experience that would help you as engineer, state them.

ASSISTANT ENGINEER—GENERAL.

AUGUST 12TH, 1904.

1. In foundation work, if you meet with quicksand, what would you do?

2. A retaining wall, vertical back will have a road filled in rear. Given, grade of road, width, etc., with two cross-sections, side slopes $1\frac{1}{2}$ to 1, compute fill for 100 ft. of the length.

3. Write a report not less than 500 words on the Riverside Drive Extension, describing the construction of a trunk sewer and transverse sewers connecting with same to drain private dwellings along the Drive.

4. Give sketches showing three types of sidewalks and state different characteristics.

5. How many cubic yards of broken stone, sand, Portland cement will it take to make 100 yards of concrete,

3-in. broken stone having 50% voids,
2-in. broken stone having 40% voids.

The 2-in. stone will fill the voids of the 3-in. stone; the sand will fill the voids of the 2-in stone; the cement will fill the voids of the sand; 10 bbl. cement will make one cu. yd. What is the percentage of the mixture?

6. Draw outline of arch, of reinforced concrete, 100-ft. span, ornamental design, and give principle for calculating same.

7. Describe the design and construction of a retaining wall.

8. How would you collect data for passing a large trunk sewer or roadway through an embankment and under the roadbed of a steam railway? Show by sketch.

9. Give the adjustments of the transit in their order, and duties of transitman when accurate work is required.

10. Give the adjustments of the level and duties of a leveler for accurate work.

11. Explain in detail a complete topographical stadia survey, its advantages and limitations.

12. Show a monthly estimate of contractor of, piles furnished in place, yellow pine lumber, brickwork, concrete above water and steel beams, prices consistent with foundation work, estimate to be assumed about middle of work.

13. Bulk in place being assumed at 100, what would be the percentage in embankment for loam, dry; loam, wet; loam, rolled; soft clay; stiff clay; sand; gravel?

14. Describe the construction of macadam roads; give their principal features and outline specifications for 100 ft. of same.

15. Describe the construction of Telford roads; state their characteristics, and write specifications for 100 ft. of same.

16. What are wooden piles used for? How is their bearing power determined?

17. Sketch sewer manhole and show connection with main sewer.

18. What do you consider a suitable maximum and minimum grade for roads? For streets?

19. A road having an 8% grade is intersected by a road having a 6% grade at right angles. Show sketches of intersection, giving all dimensions.

20. A circular sewer has inside diameter of 9 ft. Sketch sewer of another type, vertical height 4 ft., to be just as efficient.

21. Describe the method of laying asphalt pavement over old block pavement. What precautions would you take?

22. How would you drain an extensive park site?

ASSISTANT ENGINEER—AQUEDUCT COMMISSION.

Miscellaneous Questions.

1. Describe the duties of an Assistant Engineer in the Department.

2. Given a water shed, having an area of 10 sq. miles with 5% water surface. Calculate the storage necessary for daily supply of five million gallons and the dimensions of a spillway to provide for a flood of 80 cu. ft. per second per sq. mile.

3. Given an overflow masonry dam 8 ft. wide on top with vertical back, front batter 6 in. per ft., height 25 ft., weight of masonry 140 lb. per cu. ft., flood 2 ft. over, show whether or not the dam will be stable.

4. How would you measure the discharge of a small stream (*a*) on which a tight dam is situated; (*b*) without a dam.

5. Describe in detail how you would make a topographical survey and map of a water-shed, 15 miles long, 2 to 6 miles wide, for 5 ft. contours, giving organization of field and office forces, in struments and supplies.

6. Calculate the opening necessary in a road culvert having a fall of 3 in. in 30 ft., to carry the flood flow of a brook draining 1.25 sq. miles of farm country, with a general slope of 5 ft. in a thousand.

7. How would you clean the aqueduct?

8. How would you gauge the daily flow of the aqueduct?

9. What is the value of the co-efficient (n) in Kutter's formula, for the new aqueduct?

10. Give the formula for flow of water and explain terms.

11. Give the fundamental formula for amount of discharge and explain.

12. An earth dam is to be 40 ft. high. Give the best cross-section and state in detail how you would construct such a dam.

13. When springs and fissures are encountered in a masonry dam site, how would you proceed?

14. When a spring of very high head is encountered on a masonry dam site, how would you proceed?

15. What is "puddle"? What are the best proportions of material to form it?

16. How would you prevent water following a pipe line through a dam?

17. Give size, shape, etc., of stone and best method of building a masonry dam.

18. Suppose the upper surface of a dam to be vertical. (*a*) State at what depth the center of pressure of water will be located. (*b*) State what the pressure per foot of length of the dam would be, taking the depth as in (*a*).

19. (*a*) In what part of a stream is the velocity greatest? (*b*) On what functions does the velocity of a stream depend? (*c*) Describe principal ways in which average velocity of stream is obtained.

20. The velocity in a sewer running full equals the velocity when half full. Explain the reason for this.

21. State all the points to be observed in building a perfect weir.

22. What is the effect of imperfect contraction or of small depth of water over a weir. How is velocity of approach allowed for?

23. Where does the contraction of the fluid vein have to be considered in designing a pipe line?

24. State all the losses of head in a pipe line, and how they are diminished.

25. Give diagram of pipe line with undulating grade and show what is meant by hydraulic gradient. What provision should be made to insure successful work? Note: the latter part of this question refers to the case when the grade of the pipe is above the hydraulic gradient.

26. Write a report on a site for an important dam. Also on a reservoir wall, an earth embankment and a puddle core wall.

ASSISTANT ENGINEER.

Department of Water Supply and Aqueduct Commission.

1899.

1. What training and experience have you had in the design, construction and maintenance of water works?

2. (*a*) What is the maximum, minimum, and average annual rainfall in the Croton Valley?

(*b*) What proportion of this can be assumed as available for storage?

3. In building a masonry dam, state all precautions to be observed to prevent leakage and secure first-class work.

4. (*a*) In building a dam, what would you do where small springs were encountered?

(*b*) What, where large springs or considerable water?

5. State, in detail, method of constructing an earthen dam.

6. Give the different methods of measuring the velocity of flow in a stream.

(*b*) Where is the maximum velocity in cross-section of stream?

7. Given a reservoir dam, show lines of pressure and make calculation for stability. (Approximate result only.)

8. Given a stream; volume 120 cu. ft. per sec., fall 12 ft., efficiency of wheel 80%, find foot-pounds of work of stream and horsepower of wheel.

ASSISTANT ENGINEER—AQUEDUCT COMISSION.

Promotion Examination—1903—Salary $1800.

1. (*a*) What is your age? (*b*) At what technical school did you graduate? When did you graduate? (*c*) If not a graduate, under what engineer have you studied, and how long have you studied? (*d*) State fully your full experience in charge of work, with dates. Note. Omissions or discrepancies in dates count against the applicant.

2. State fully the duties of the position to which you desire promotion.

3. Describe the operation of cleaning the aqueduct.

4. State how the daily flow in the aqueduct is gauged.

5. In the application of Kutter's formula in computing the flow, state what the value of the coefficient (*n*) is found to be.

6. In computing the flow in an open channel by the ordinary formula, what quantities are required?

7. Suppose a dam is to be founded on rock, and on uncovering the rock it is found to be seamy, with water coming up at points, what would you do?

8. Suppose there is a spring with considerable head, what can be done?

9 and 10. Draw a section of an earthen dam to cross a valley, the depth to rock below the surface to the ground being 25 ft. at the deepest point, and the water surface to be 30 ft. above the ground at the same point. Give every detail to produce safe work and give reasons.

11. What can be done to prevent water from flowing along a pipe which passes through a reservoir wall?

12. In laying up a masonry dam, what measures as to shape of stone, cutting same, bounding same, and laying same, will tend to make the tightest work?

13. (*a*) Describe the material which makes the best puddle. (*b*) Suppose you have to prepare puddles from materials on a work, how would you do it?

14 and 15. Write a report on your examination of a valley for the best location of a dam. Describe fully the examination made, the result of your examinations, and the reason for the location you have made.

ASSISTANT ENGINEER—AQUEDUCT COMISSION.

SALARY $1800. JUNE 21, 1904.

1. Does the quality of cement (particularly of Portland cement) for hydraulic work, depend in any way upon its storage?

(*a*) If so, state clearly how it is affected by storage.

(*b*) State what may be the after effect upon a structure of lack of care in this respect.

(*c*) Describe the proper storage of cement.

2. (*a*) Upon what does the imperviousness of concrete to the passage of water depend? (*b*) Describe clearly and fully the method you would take to determine the best proportions of the several ingredients in order to make water-tight concrete.

3. State what you know about the *mechanical* anaylsis of sand, gravel, etc.

4. When an earth bank for a reservoir, or canal, is to be placed on earth, does the surface need any preparation, and if so, what and why?

5. (*a*) Suppose a masonry dam is to be founded on rock, and after excavating to it, the rock is found to be seamy with water flowing from the seams. How should the rock be treated? (*b*) If the springs are very strong flowing, what must be done? (*c*) In such a dam, what would determine the depth to which examinations by drill or otherwise, should be carried?

6. Make a sketch showing how the foot of a slope wall on the inside of an earthen reservoir bank should be supported and give your reasons for the construction shown?

7. Write a suitable clause for the specifications for the stone work in a large masonry dam, describing the character of the stone as to shape and dimensions and the bond to be observed? State your reasons? (Stone setting is asked in next question.)

8. Describe minutely everything to be done in setting a large rubble block in the heart of such a dam from the time the stone is lifted until the setting is complete? (*b*) What objections, if any, are there to the use of grout in such a case? State fully and clearly.

9. (*a*) Describe clearly the usual method of tunneling in sound rock where timbering is not required? (*b*) How may the progress and cost of a tunnel be affected by carelessness of the Contractor in blasting and otherwise?

10. Sketch a form of centre with approximate dimensions to be used in treacherous rock in a tunnel like that of the Aqueduct?

11. (*a*) In building a large sewer, or a piece of the Aqueduct where quicksand is encountered, how do you proceed to get sound work? (*b*) Under what conditions does quicksand of itself make a safe foundation?

1. Find the area of an ellipse, whose diameters are respectively 10 ft. and 6 ft.

2. Find the solid contents of the frustum of a cone, whose radii are respectively 7 in. and 11 in., and whose height is 17 in.

3. In a rectangular borrow-pit 50 ft. by 40 ft., the following are the cuts at 10 ft. intervals, both ways. Compute the cut (omitting side slopes) by the shortest method of averages.

7.	5.6	6.1	6.7	7.3	8.
6.6	5.3	6.	6.5	7.	7.5
6.3	5.2	6.	6.2	6.9	7.2
6.5	5.1	5.9	6.	6.5	7.
6.	5.	5.6	5.9	6.3	6.6

4. The average section of a stream for a distance of 100 ft. is as follows; the fall of the stream is in the same distance 0.12 ft.:

25 ft. Left.	Depth	=	0	ft.
15 " "	"	=	6	"
5 " "	"	=	8.5	"
Center	"	=	10.	"
5 " Right	"	=	8.5	"
15 " "	"	=	6.0	"
25 " "	"	=	0.0	"

Take (c) = 88 in the formula $V = c \sqrt{R\ S}$ and determine the value of V.

1. What is your age?

2. Have you graduated from a technical school or college? (*a*) If so, give name and location of same. (*b*) State the date of entrance and of graduation?

3. Have you studied under an Engineer in addition to a technical course? (*a*) If so, give his name and residence. (*b*) State what your studies were under him. (*c*) State how long you were a student under him. (*d*) Give the date when you began with him and when you finished. (*e*) State what work in the field you did while studying under an Engineer.

4. In addition to your experience while a student, state every other item of practical experience you have had. (*a*) In each case state location and kind of work. (*b*) State in every case what you had to do with it personally—that is, your position and specific duties. (*c*) State when you began the work in every case, and when your connection with it ceased.

5. State any other facts or experience which tend to make your services of value as an Assistant Engineer.

6. Give the names and addresses of at least two persons to whom application can be made for verification of the answers to the foregoing questions.

BOARD OF WATER SUPPLY.

Assistant Engineer—General—Technical.

Salary $1 350 per Annum.

October 12, 1905.

Note: Elaborate discussions are not required. Clear, concise answers covering the essential points will receive highest rating.

1. State (without describing in detail) the several adjustments, in their proper order of (*a*) the surveyor's transit; (*b*) level.

2. Explain briefly the method of stadia survey and show a form for notes, filling in such as are taken in the field and leaving blank those which are worked out in the office.

3. Explain how a drainage area is determined.

4. (*a*) How is the total rainfall for any area determined? (*b*) How the available rainfall? (*c*) State the full information for both necessary for purposes of securing water supply.

5. Describe briefly the several methods of measuring the flow of water in streams.

6. Name the watersheds available for supply of New York City and state briefly the advantages and disadvantages of each.

7. (*a*) Give the Chezy formula and explain its terms. (*b*) In what does Kutter's formula modify it?

8. State the causes of failure of retaining walls and the precautions necessary to prevent failure.

9. State briefly the important points regarding mixing (by machine) and placing heavy concrete masonry.

10. Describe briefly the several methods of sinking wooden piles and the conditions under which each would be used.

11. Discuss briefly the methods of handling quicksand in constructive work.

12. Draw a section of an earth dam, the depth of rock below earth surface being 20 ft.; the water surface to be 25 ft. above the ground. Show every detail to produce safe work.

13. Explain briefly the method of tunneling through rock.

14. Same through soft mud below water.

15. State the prismoidal formula and show by sketches its use in calculating the contents of an earth embankment.

Mathematics.

Give all the figuring on the ruled sheets.

1. Extract the square root of 2030.4063036 to four places of decimals.

2. Reduce 35.2 in. per second to feet per minute and miles per hour.

3. Find the area of a triangle the sides of which are 50, 60 and 70 ft. respectively.

4. How many cubic feet of water per second will be discharged by a canal 125 ft. wide at top, 75 ft. wide at bottom, 10 ft. deep and 2 640 ft. long with a fall of 40 ft. (Take c equals 88.)

5. What is the weight of a cast-iron pipe 12 ft. long, 4 ft. inside diameter, 1 in. thick, allowing $2\frac{1}{2}\%$ for increase of metal in hub and spigot?

Report.

Assume reasonable facts and write a suitable report of not less than two nor more than three pages on any one of the following subjects:

(*a*) The general avalability of the Watershed as a source of supply for New York City.

(*b*) The Hudson River as a possible source of supply.

(*c*) A proposed filtration system.

(*d*) A proposed storage reservoir adjacent to New York.

(*e*) The comparative merits of a steel re-enforced concrete conduit and a brick conduit.

(*f*) Possible methods of reducing water consumption in New York.

ASSISTANT ENGINEER—INTERMEDIATE GRADE.

SALARY $1 650.

OCTOBER 17, 1905.

1. Describe the making of an accurate triangulation survey.

2. State the principle (*a*) of the pressure of water; (*b*) of the siphon.

3. Discuss the use of steel to re-enforce concrete.

4. Explain the method of designing a steel water tower 100 ft. high, 40 ft. in diameter.

5. Outline specifications for brick mortar and work of construction of a large brick conduit.

6. Show by sketches and describe the method of carrying a large conduit over a marsh.

7. Describe clearly the method of accurately determining the character of foundation for an important dam.

8. Explain in detail the most accurate way of gauging the velocity of a stream.

9. Explain the method of designing a masonry arch viaduct to carry an aqueduct.

10. State what you know regarding evaporation from water surface, from snow and ice and from earth.

11. State what you know regarding sedimentation in reservoirs and its prevention.

12. State the important points to be considered in the construction of an open canal for carrying water supply.

13. Describe the theoretical design of a heavy masonry dam.

14. State the important details of construction of (*a*) a heavy masonry dam; (*b*) such features as are peculiar to concrete.

15. Show a proper form for an intermediate monthly estimate to a contractor of following items, with reasonable cost prices: (*a*) Clearing and grubbing; (*b*) Earth excavation (with convenient waste); (*c*) Rock excavation (in considerable quantity); (*d*) Sheet piling, left in place; (*e*) Concrete; 1, 3, 5 (in mass); (*f*) Random, coursed rubble monumental masonry.

ASSISTANT ENGINEER—HIGHEST GRADE.

SALARY $2 000.

OCTOBER 17th, 1905.

16. Describe how the flow of water in circulating pipes is affected by friction, stating the various cases and assigning values for each and quoting your authority.

17. Explain how to ascertain the time required to empty a reservoir.

18. State all the important points which should be considered in the choice of a reservoir site for gravity water supply.

19. Design an "aqueduct" section conduit of concrete re-enforced with steel.

20. Describe fully a system of water filtration suitable for a large city.

21. A stone arch bridge must take the drainage of 5 000 acres. How many cubic feet per second must be carried? (Use formula Q equals $c\ y\ \sqrt[4]{S\ O^3}$, in which c equals 50, y equals 1.5 and s equals 12.

22. Assume bridge semi-circular for 50 ft. roadway; design opening and show by sketches approximate construction.

23. State briefly the successive steps necessary to secure information regarding the availability of a watershed for purposes of water supply.

24. Explain the theory of rain and that of the amount of rainfall as affected by winds and mountain ranges.

25. Discuss the important points to be considered in the construction of a large distributing reservoir as is proposed near Yonkers.

DEPARTMENT OF DOCKS AND FERRIES—PROMOTION TO ASSISTANT ENGINEER.

AUGUST 18th, 1896.

1. Describe in full, detail of operation of making a hydrographic survey for a pier on the North River, together with the location of property lines.

2. Give specimen page of a note book containing such a survey.

3. Describe methods pursued in obtaining a knowledge of the earth strata, etc., at the site of the pier.

4. Give careful pencil sketch, with dimensions of the standard form of wall used by the Department where the mud is very deep.

5. What type of wall is used in hard bottom and what type where rock is near the surface?

6. State as fully as possible the reasons for the adoption of this method of construction.

7. What is the angle of repose as applied to earth and what relation does it bear to the angle of maximum pressure?

8. In case of retaining wall, at what angle will the earth sustain rupture, in case of the movement of the wall?

9. In what ways do retaining walls fail?

10. Without increasing the dimensions of a retaining wall what precautions in filling behind it, will increase its safety?

11. A derrick has a mast 40 ft. high, a beam 35 ft. long, and a topping lift 25 ft. long. There is a weight of 10 tons supported at the end of the beam. What is the horizontal pressure at the top of the mast?

12. In the testing of elastic material, such as iron, what is the meaning of the term "elastic limit" and about what proportion does the stress at that point bear to the ultimate strength?

13. What are the respective weights of a cubic foot of fresh and salt water?

14. What is the standard weight of the atmosphere?

15. In using drift bolts for fastening timber what precautions are necessary to obtain the greatest possible holding power in the timber?

16. Describe the building of a standard concrete block in detail.

17. Describe the setting and lining up of one of these blocks.

EXAMINATION FOR PROMOTION TO ASSISTANT ENGINEER.

Department of Docks and Ferries.

December 1st, 1899.

1. State your age and training and experience you have had in any form in connection with the design, construction or maintenance of wharves, docks, bulkheads or any other works of a similar nature.

2. What pressure per square foot of foundation would you consider it safe to allow on a gravel bottom or one of coarse sand, when it can be protected from wash or other disturbance?

3. (*a*) On what elements does the bearing power of a pile depend?

(*b*) How would you decide upon the safe load to be applied to any given pile which you have seen driven?

4. When the foundation of a bulkhead is on rock, is any preparation of the rock ever necessary; and if so, what, and for what reasons?

5. Suppose a pile near the outer end of a pier to have an average diameter of 15 in., and the depth of water to be 35 ft. What would be the total pressure against its surface resulting from a tidal current with an average velocity of 4 miles per hour?

6. (*a*) Give careful sketches (plan, etc.), on a large enough scale to show clearly every part (fastenings included) of the outer 80 ft. of a pier 60 ft. in width, with dimensions of parts.

7. Give careful sketches of one panel of an iron and slate roof and supports for such roof, dimensions of parts not required, but constants for loading, strength of iron, channels, angles and riveting to be given.

Second Paper.

1. When a bulkhead must be built on material which is compressible and unstable to a considerable depth, show how substantial work may be done and explain principles governing the design of such work.

2. State all requirements of a strictly first-class pile for important work.

3. (*a*) State the difficulties encountered in using fresh concrete under water, and all the ways you know of for doing such work in a reasonably satisfactory manner, when it must be done.

(*b*) State what tests a cement should stand which is to be used in the manufacture of bulkhead blocks.

4. (*a*) State what ingredients in cement are detrimental?

(*b*) To get the very best hold in timber when round bolts are used, how must the work of boring be done and what precaution must be taken?

5. Describe the best method of setting concrete blocks for a bulkhead under water, including location as to line and level and every element of good work.

6. Describe in full detail the method of sounding an area under water in a tideway so as to get accurate depths and locations.

7. To what plane of reference should surroundings in a harbor be referred, and for what reasons?

ASSISTANT ENGINEER—DEPARTMENT OF DOCKS.

1. What experience have you had in the design, construction and maintenance of docks and bulkheads?

2. Sketch section of standard bulkhead where good bottom is found at moderate depth.

3. How should cement be tested for use under water?

4. Sketch section of standard bulkhead where poor bottom is found at considerable depth.

5. How would you determine safe bearing power of piles?

6. State all the methods you know of for sounding under water.

7. Give all details of making large concrete blocks used in bulkheads.

ASSISTANT ENGINEER—SEWER DEPARTMENT

APRIL 24TH, 1899.

1. What methematical knowledge should an assistant engineer in the sewer department possess? Give your reasons.

2. What are all of the duties that an assistant engineer may be called upon to perform?

3. Describe what experience you have had in this work that entitles you to promotion.

4. Explain in detail all the refinements that should be observed by the leveler and rodman in running an accurate line of levels.

5. What method should a transitman and flagman observe in running a long transit line accurately?

6. (*a*) How frequently should receiving basins be placed on a street? What rule governs this?
(*b*) How frequently should manholes be placed on a street? Give your reasons.

7. Should a sewer built to carry off the rainfall from a thousand acres be ten times as large as one built to carry off the rainfall from 100 acres? Give your reasons.

8. How would you measure the quantity of water flowing in a sewer?

9. Calculate the diameter of a sewer to carry off one inch of rain per hour from 100 acres, the grade being 1 in. in 100 feet.
Assume formula as follows:

$D = \sqrt[5]{Q^2 \ L \div 1.5 \ H}$.
$Q =$ Cu. ft. per sec. of water discharged.
$L =$ Length of sewer in feet.
$H =$ Fall per feet.
$D =$ Diameter in feet.

10. State what you understand by "separate" and "combined" systems of sewers, and which you consider the better in any case.

11. Describe and sketch the best bond for use in brick sewers and state why.

12. Describe the proper method of joining a brick sewer to main sewer as regards to shape, grade, and everything that may appertain thereto, with reasons.

13. Sketch a complete cross-section of a large brick sewer (giving dimensions) to be built across a very soft piece of ground, showing whole construction, including foundation.

14. How would you determine the safe weight to put upon a given pile you may have seen driven?

12. (*a*) What is the largest size of vitrified pipe in use?

(*b*) Give in detail the best manner for laying pipe so as to give the freest flow in a sewer of small descent.

16. Write a report, as an assistant engineer, to your superior on the most important work you have been connected with; giving a description of the work, what has been accomplished; the reason why certain plans were followed, and everything else that you think would be of account in such a report.

ASSISTANT ENGINEER—SEWER DEPARTMENT.

New York City, November 29, 1899.

1. What training and experience have you had in the design, construction and maintenance of sewers?

2. Sketch standard manhole for 36-in. brick sewer with 12-in. pipe branch; show elevation of section across sewer and plan at about flow line.

3. (*a*) For what rate of rainfall should sewers in New York City be designed?

(*b*) What proportion of this is assumed as reaching the sewer? Is it a constant, and show, if you can, how this is introduced in the formulas for diameter of sewers.

4. When would you use the egg-shaped section for sewers?

5. When is the velocity greatest in a sewer, when it is running full or half full or how is it?

6. (*a*) What is meant by hydraulic mean radius?

(*b*) Does resistance to flow depend on this, and how?

7. What is the least allowable velocity of flow in sewers, and why?

8. What is the best bond for brick sewers?

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

ASSISTANT ENGINEER
GENERAL, AQUEDUCT, DOCKS, SEWERS & HIGHWAYS

TYPICAL QUESTIONS AND ANSWERS

TYPICAL QUESTIONS AND ANSWERS.

ASSISTANT ENGINEER—GENERAL.

1. What are the duties of an assistant engineer?

He is usually required to take responsible charge of one or more parties or sections of work. He must direct such work, look after all details, handle his men to advantage and protect the interests of the City. He may be placed in charge of surveys for topographical, hydraulic, drainage, street opening and other purposes, or on construction of bridges, sewers, water works, docks, highways, &c. He is often required to prepare plans, specifications and estimates or examine and report on the condition and quality of work in progress.

The assistant engineer is expected to be familiar with the work of the computer, draftsman, surveyor and estimator, and to possess executive ability, initiative capacity, tact and judgment.

2. What is meant by the acceleration of gravity?

The acceleration of gravity is the increase in the velocity of a freely falling body. A body starting from a state of rest, acquires a velocity of 32.16 ft. at the end of the first second, 64.32 at the end of the 2nd second, &c. The acceleration (g) is thus 32.16 ft. per sec.

3. Through what distance does an ordinary body fall in the 1st, 2nd and 3rd seconds; what is its velocity at the end of each second, in feet?

Distance passed through in first second $= S_1 = 16.08$ ft.
" " " 2 seconds $= S_2 = 4 \times 16.08$.
" " " 3 " $= S_3 = 9 \times 16.08$.
" " " n " $= S_n = n^2 \times \frac{1}{2} g$.

Therefore

Distance passed through in 2nd second $= S_2 - S_1 = 3 \times 16.08 = 48.24'$.

Distance passed through in 3rd second $= S_3 - S_2 = 5 \times 16.08 = 80.40$.

Distance passed through in nth second $= S_n - S_{n-1} = [n^2 - (n-1)^2] \times 16.08$.

The velocity at the end of the nth second $= n \times 32.16$.

4. Do these distances hold good at all points on the earth's surface? If not, where are they least and where most?

The value of the acceleration of gravity, and therefore the quantities depending upon it *are not* the same in all parts of the earth. It is least at the equator and greatest at the poles. It is modified by the form and rotation of the earth.

The earth being an ellipsoid and not a sphere, the surface at the equator is farther from the center than it is at the poles, and the velocity of rotation at the equator is therefore also greater; the result being that g at the equator is less than at the poles, the difference being about 0.16 ft. per sec.

5. What is the specific gravity of a body?

The specific gravity is the weight of the body as compared with the weight of an equal volume of pure water, at 4° C. It is equal to its weight in air divided by the loss of weight when immersed in water.

6. What is the standard for solid and liquids?

The standard is pure water at 62° F. 32° F. and 39.1° F. are sometimes used as standard temperatures.

7. What for gases?

The standard for gases is air at atmospheric pressure (15 lb. per sq. in), and at 32° F.

8. What is the standard weight of the atmosphere?

The standard weight is 0.080728 lb. per cu. ft.

9. What are the respective weights of a cubic foot of fresh and salt water?

Fresh water weighs about 62½ lb. per cu. ft.
Salt water weighs about 64 lb. per cu. ft.

10. Give the weights of cast iron, wrought iron, water, moist sand, concrete, brickwork (close joints), and limestone masonry.

Weight of cast iron	= 450	lbs. per cu. ft.
" " wrought iron	= 480	" " "
" " moist sand	= 100	" " "
" " brickwork	= 100	" " "
" " limestone masonry	= 150	" " "
" " rubble	= 150	" " "
" " concrete	= 130	" " "
" " cement natural	= 60	" " "
" " cement Portland	= 80	" " "
" " mortar	= 100	" " "

11. What is the center of gravity of a body?

The center of gravity is that point through which passes the resultant of all the forces of gravitation acting on the elementary particles of the body so that if suspended at this point all the parts will be in equilibrium.

12. How is it found?

In regular homogeneous bodies it coincides with the center of figure.

The position in irregular bodies may be found by experiment or by dividing the body into simple figures in which the position of the center of gravity is known and then computing by moments the position of the center of gravity of the entire body.

13. Where is the center of gravity of a homogeneous body whose sides are all rectangles?

At the center of figure.

14. What is the ordinary velocity of sound per second, and does it vary with the temperature or not? If so, how?

The ordinary velocity is 1 090 ft. per second in air at 32° F. It *varies* with the temperature, increasing about a foot for each degree increase in temperature, being about 1 060 ft. per sec. for 0° F., and 1 160 ft. per sec. for 100° F.

15. What is the boiling point of water at sea level, and how does it change as you rise above sea level? What change for 5 000 ft. rise?

At sea level water boils at 212° F. The boiling point decreases about 1° for each 520 feet rise, being about 202° at 5 000 ft.

16. State (without describing in detail) the several adjustments in their proper order of (*a*) the surveyor's transit; (*b*) level.

(*a*) The adjustments of the transit are:

1. Adjustment for parallax—to bring the image in the plane of the cross hairs.

2. Adjustment of the plate levels—to make them perpendicular to the vertical axis, so that the plate will be horizontal when bubbles are in the center.

3. Adjustment of the cross hairs—to make the line of sight perpendicular to the horizontal axis, so that it will generate a plane as telescope is revolved in altitude.

4. Adjustment of the horizontal axis—to make it perpendicular to the vertical axis, so that the line of sight will generate a *vertical* plane as telescope is revolved in altitude.

5. If telescope is provided with a bubble tube the axis of the tube must be made parallel to the line of sight, if the instrument is to be used for leveling.

(*b*) The adjustments of the level are:

1. Adjustment for parallax.

2. Adjustment of cross hairs—to make the line of sight coincide with the axis of the telescope.

3. Adjustment of the long bubble—to make the axis of the tube parallel to and in the same plane with the line of collimation.

4. Adjustment of the Ys or standards—to make the axis of the pivot rings perpendicular to the vertical axis, so that the bubble will remain in center in all positions of the telescope.

17. Describe the making of an accurate triangulation survey.

A reconnaissance is first made of the area to be surveyed, with a view to the best possible location of base lines and triangulation stations.

Base lines as long as possible near each end of the area are selected, monumented, and chained, using all possible refinements so that the error does not exceed 1 in 100 000.

The stations at the ends of one of the base lines are then occupied by the transit instrument, and angles read to all visible triangulation stations which have previously been selected or established.

The instrument should be the best obtainable, the adjustments as perfect as possible and all precautions taken to eliminate error. The angles should be read by repetition and series and the work held to a possible error of one second per angle or less. The closing angle to complete the horizon should be taken at each station occupied.

Each triangulation station is then occupied in turn, angles being taken to all others visible, until every possible station, including those at the ends of the second base line, have been occupied.

The angles are then examined, errors distributed and the co-ordinates of each station computed, starting with the co-ordinates of either base and checking on the length and bearing of the other.

18. Describe in detail how you would make a topographical survey and map of a watershed 15 miles long, 2 to 6 miles wide, for 5 ft. contours, giving organization of field and office forces, instruments and supplies.

The first consideration is the amount of time given to complete the survey. Taking one year as the basis, the work would be divided into three divisions, each about five miles long, headquarters being centrally established for each division.

The organization of the forces would be as follows:

Chief Engineer in Charge of Work.	Division A. 3 Field Parties and office staff...	1 Assistant or Division Engineer in charge. 3 Transitmen or Assistant Engineers in charge field parties. 3 Levelers assigned to field parties. 10 Axemen and Rodmen. 3 Draftsmen and Computers. 2 to 4 Laborers—(Drivers or Caretakers). 3 to 5 Computers and Draftsmen in office.
	Division B. 3 Field Parties and office staff.	Same as Division A.
	Division C. 3 Field Parties and office staff..	Same as Division A.

The equipment of each division would be 3 transits (stadia) and necessary bobs, sighting apparatus 3 levels and necessary leveling rods, 3 plane tables and necessary stadia rods.

A liberal supply of tapes, axes and usual surveyor's sundries.

Two horses, a stage and a buggy, necessary attachments, office furniture, draughting materials, etc.

The first step in the survey is to establish a primary traverse system (which should be tied to some established lines) around the reservoir site, monumenting all principal points balancing, and plotting the work. The error in the primary traverse work should not exceed 1 in 50 000. The main traverse can then be divided into squares having sides of about ½ mile in length, all stations being referenced, co-ordinates computed and plotted.

During the progress of the traversing, lines of bench levels starting at a known point should be run accurately around the watershed following the main traverse lines, the elevations of all stations being determined.

Plane table sheets covering about $\frac{1}{2} \times 1$ mile of area and mounted on rollers should in the meantime be prepared by the draftsman, the scale being 1 in. = 100 ft.

The established traverses should be plotted on the sheets and the field parties given a list of all references, co-ordinates, benches, etc., that they may have occasion to use.

Sheets are assigned to the several parties, who fill in all topographical details, recording elevation of all hollows, ridges, water surfaces, changes of slope and grades of roads and other points controlling the positions of contours. The location of all points may be obtained with the stadia and vertical angle and the contours interpolated, or where the ground is not too steep the contour may be directly "followed" with the level and rod and correctly drawn on the sheets. All buildings, fences, property lines, roads, streams, ponds, culverts and all other details must be obtained.

Additional stations and benches are established by the several parties as required.

As each sheet is finished it should be turned over to the draftsman and inked while the details are fresh in the mind, and other sheets assigned to the field party until the entire area has been mapped. As adjacent sheets are completed they are carefully compared so that any error in the work can be detected.

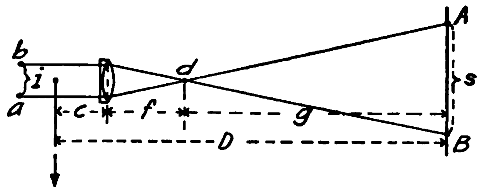
19. Explain briefly the method of stadia survey and show a form for notes, filling in such as are taken in the field and leaving blank those which are worked out in the office.

The transit should be supplied with a compass and a vertical arc. The rods should be of the self-reading pattern, easily read from the instrument. Make all the adjustments and note the index error of the vertical arc. Measure the focal distance (f) of the objective and the distance (c) from the reticule to the objective, giving the stadia constant ($f + c$).

Stake out a line about 800 ft. + ($f + c$) setting stakes at $100 + f + c$ from point of beginning and at every 100 ft. point thereafter.

Set up transit at the zero of the line and take readings on stadia rod held at each stake. The hairs should be adjusted so that 1 ft. on rod will equal 100 ft. ($+ f + c$) from instrument, or

the ratio per hundred feet may be obtained from the observed readings.



$$s : g :: i : f$$

$$g = \frac{f\,s}{i} = k\,s \qquad D = k\,s + (f + c).$$

Run a traverse around area to be surveyed, obtaining lengths of the sides with the stadia, and their azimuths; also establish bench marks around the traverse, obtaining elevations of all stations.

The azimuth of the starting courses may be obtained by an observation on Polaris or by traversing from known lines. To get the azimuth of the succeeding course, set vernier on azimuth of back course, sight on back station with the telescope normal, plunge telescope and turn on forward station. The reading on the limb will be the new azimuth. The back sights and fore sights should be taken and averaged for the lengths of the courses and the lengths reduced to the horizontal.

After the traverse has been closed, set up on each transit station, take shots on all prominent points, such as tops of ridges and bottom of hollows, fences, buildings, roads, streams, culverts, noting the azimuths, distances to each and vertical angles when the latter exceed about 5°. All other details should be located and amplified by sketches when necessary.

Auxiliary stations should be established when required, as judgment dictates.

When a station is once occupied care should be taken that all necessary data are obtained from it.

Whenever the transit or level is set up at a new point a check reading should first be taken on an established point to check the orientation and the H. I.

By means of a stadia chart or table the observed distances are reduced to the horizontal. The notes should be plotted as soon as possible while still fresh in the mind. (For inclined sites, distance $= k\,s\,\cos.^2 a + (c + f)\cos.\,a$ and diff. elev. $= \frac{1}{2}\,k\,s\,\sin.\,2a + (c + f)\sin\,a$.

The contours may be interpolated between the plotted points or they may be directly "followed" and changes in direction located.

FORM OF NOTES.

Date.....					Party {				Remarks and Sketches.
Sta	Azim.	Distance.			V. A.	Hor. Dist.	Diff. in Elev.	Elev.	
		F. S.	B. S.	Av.					
*F	*F	*F	*F	†O	*F	†O	†O	†O	

* Columns marked F are filled out in field.
† " " O " " " " office.

20. What methods are usually employed in calculating earthwork? Describe them.

There are two methods in common use:

1. The average end area method.
2. The prismoidal formula.

In the first case volume included between two successive stations

$$= \frac{A + A_1}{2} \times l$$

A = area section at one end.
A_1 = area section at other end.
l = distance between ends.

By prismoidal formula:

Vol. $= (A + A_1 + 4Am) \times \frac{l}{6}$. Am = Area of section midway between A and A_1.

The sum of all the partial volumes will give the total volume.

The areas of the cross-section at any station may be obtained—

1. By means of the planimeter.
2. By direct computation, from the cuts and fills.
3. By plotting on cross-section paper and counting squares.
4. By cutting sections out of cardboard and weighing same, the unit weight being known.

21. What are the several qualities of cast and wrought iron which make them useful for various classes of engineering construction? Describe briefly the work for which each is well adapted and in general the methods by which you would test them.

Cast iron is durable, possesses great strength in compression, and can be readily cast in any desirable shape, making it a convenient material to use for water pipes, columns, column footings, bed plates for machinery, etc.

It, however, is brittle and should not be used where subject to heavy vibration, impact or tensile stresses.

In inspecting castings, look for honeycomb. Blow holes or sand holes when filled with sand or loam are detected by a dullness in sound on tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges; warped castings and those of incorrect dimensions should be rejected.

For testing the strength, bars 14 or 26 in. long, 3 in. wide and 1 in. thick are prepared and the breaking load transversely and in tension obtained, the resulting deflection and elongation being also noted.

Two principal varieties of cast iron are made: White, which is hard, brittle and difficult to work; gray, which is soft, tough and malleable when cold.

They differ in the amount of carbon in chemical combination.

Wrought iron is adapted to structures which are subject to alternating compressive and tensile stresses, but in which the unit stresses are not excessive, such as rivets, beams, girders, truss members, columns, etc. The metal is durable, malleable, elastic and readily worked.

In inspecting wrought iron look for "cold short" (containing phosphorus), indicated by bright crystalline fracture and discolored spots; also for red short (containing sulphur, arsenic, etc.), indicated by cracks on edges of bars.

Tough iron has a fine, fibrous and close texture.

Wrought iron is tested by bending prepared bars hot and cold. No fracture should result.

The tensile strength is determined from test pieces usually about 18 in. long by 1 in. wide, and the original thickness.

22. Name the common kinds of wood used in building and state the purpose for which each is used.

Ash—Used for interior and cabinet work.
Cedar—Used for posts, ties and fences.
Cypress—Used for interior work.
Elm—Used for ties and bridge timber.

ruptured suddenly the fracture has a granular appearance with the surface usually even and at right angles to the length. The fracture is often cup-shaped. The color is light pearl-gray.

The fracture of cast iron should be of a light bluish-gray color and of close-grained texture with considerable metallic luster.

(*b*) Good wrought iron is indicated by small crystals of a uniform size and color, and fine, close, silky fibers.

136. Describe the appearance of each of the above when the material is poor.

Fracture of poor steel is dull and sandy looking without luster or sheen; yellowish color; burned steel has a whitish hue and granular fracture.

Fracture of poor cast iron shows mottled surface, either with patches of darker or lighter iron, or it may have crystalline patches; very bad specimens also show air holes.

Fracture of poor wrought iron shows coarse crystals, blotches of color, loose, open and blackish fibers. Flaws in the fractured surface indicate defects in the processes of manufacture.

137. State what a drift pin is for, and whether it has any effect upon the strength of the material in which it is used, and what that effect is.

A drift pin is a round piece of steel, made slightly tapering, used for bringing pieces together preparatory to riveting.

The use of a drift pin to enlarge a hole causes a hardening of the material around same, and a consequent loss of ductility and an increase in the elastic limit of the latter. This is considered very injurious. Specifications prohibit the use of drift pins except for bringing pieces together.

138. (*a*) Describe the proper way of testing the thickness of a C. I. column.

(*b*) Describe carefully the method of testing the soundness of a C. I. column.

(*c*) What parts of a C. I. column require special care in examination to prevent accident?

(*a*) The thickness of a C. I. column is usually tested by drilling a $\frac{3}{8}$-in. hole at one or more points and measuring same. A round column may be laid on a pair of rails set horizontally. The column is pushed slightly and note is made whether it rolls uniformly or always settles on one side. In the latter case the metal is thicker on that side, and a test-hole should be drilled on the opposite side.

(*b*) The soundness of a C. I. column is tested by tapping the

column all around with a hammer and noting the sound. Blow holes or sand holes filled in with sand from the mould give a dull sound upon tapping. Cracks are also indicated by a dull sound. The middle of the column must be examined carefully for cold short.

(*c*) The connections of lugs, brackets, capitals and bases require close examination to discover flaws, shrinkage and blow-holes.

139. (*a*) Suppose a cast iron column to be ½ in. too short, what would you do?

(*b*) Suppose such a column to have one of the ends not turned square, what would you do?

(*a*) If the column is ½ in. too short, put a ½-in. steel plate under it to bring it to the proper elevation.

(*b*) If one of the ends is not turned square the column should be sent to the nearest shop and corrected, provided that too much metal is not removed. Sometimes it may be allowable to leave the column as it is and put a wedge-shaped shim plate between the incorrect end and the next column. In a very bad case the column must be rejected.

140. Where, in a detail drawing, a number of small circles are shown in some parts, all filled in with hatching, or entirely black, what does it indicate?

Such circles represent holes for field rivets or field bolts.

141. Would you consider it necessary to make any inspection of girders, posts or other iron work after delivery on the ground before erection? If so, state exactly and fully what that inspection should be.

The iron work received on the ground must be examined to see if it tallies with the invoice sheets, and every piece must be closely scrutinized to see if the shop inspector's stamp has been placed thereon. The inspector of erection must also examine all material received to see that it has not been bent or otherwise injured during transportation from the shops. Anything overlooked by the shop inspector must be corrected by the inspector of erection.

142. Suppose that during erection certain rivet holes do not come "fair," how should such errors of every kind be corrected?

Holes which do not match exactly during erection must be enlarged slightly by reaming. If a hole in one or more connecting plates has been omitted, it must be drilled in the field.

If a hole is present where no rivet or bolt is required it should be plugged up with lead.

143. Is there any difference in the strength of riveting done in the shops and on the work? If so, which is the stronger and why?

Riveting done in the shops is considered stronger than that done in the field. This is especially true of hand-driven rivets. With the modern pneumatic riveters, there should be no difference in the strength of shop and field work, although most specifications require 25% more field than shop rivets in hand-driven work, and about 10% in the case of machine work. Shop rivets are considered stronger, as they are driven under more favorable conditions as to handling of materials, heating of rivets and inspection of work. Of course machine-driven rivets can be more uniformly made than hand-driven.

144. How would you inspect a job of riveting?

With a special hammer weighing about a pound, blows are struck sharply on each side of the head of the rivet.

Loose rivets will be indicated by jar or rattle.

Also examine edges of rivet head, observing that there are no marks of caulking tool. See that the heads are concentric, fit closely all around and are free from cracks, and that no impress on the metal around the head has been made in driving the rivet.

The rivet heads should be full size.

145. In inspecting a heavy casting as a base of a column, what defects would you look for?

In inspecting castings look for honeycomb. Blow-holes or sand-holes when filled with sand or loam are detected by a dullness in sound, upon tapping. Examine also for shrinkage cracks, large ridges at partings and flaws on edges. Warped castings or those that are incorrect in dimensions should be rejected.

146. (*a*) Where bolts are to be used permanently in a piece of work, how is the strongest job obtained? (*b*) Which is the stronger, bolting or riveting, and why?

(*a*) By drilling the holes in connecting parts, using a steel templet if necessary. (*b*) Riveting if well done is stronger than bolting, because the rivet is forced into the hole and fills it completely, and the rivet heads upon cooling bind the members more firmly together. In riveted work, moisture cannot work into the joint and cause rust and deterioration.

147. Are any precautions against wind ever necessary in the erection of iron work in a building, and if so, what?

During erection the wind bracing and brackets must be connected up as quickly as possible, especially in a skeleton building in which the steelwork is carried up rapidly. Otherwise there may be a failure of portions of the ironwork during a high wind due to overstraining.

148. How should specimens for testing be chosen and prepared to fairly show the quality of (*a*) wrought iron; (*b*) cast iron?

(*a*) The test specimen for wrought iron can only be taken after the material is rolled and must be cut from the full-sized bar. The test piece for tensile strength, limit of elasticity, and ductility is usually cut about 18 in. long, the same thickness as the finished bar. (*b*) The test-bars for bending of cast iron are usually 3 in. wide by 1 in. thick and either 14 in. or 26 in. long. One is poured before and one after the casting is poured. The bars for tensile strength are about 18 in. long and usually turned down in a lathe in order to remove the exterior scale. They are marked similar to the specimens for wrought iron or steel.

149. What conditions or quality of material or manufacture are indicated by the following tensile test results: (*a*) Elastic limit 38 000 lb. per sq. in., and ult. strength 45 000 lb. per sq. in. (*b*) Ultimate strength 80 000 lb. per sq. in., elongation in 8 in., 10%. (*c*) Ultimate strength 80 000 lb., elongation in 8 in., 25%. (*d*) Ultimate strength 56 000 lb., elongation in 8 in., 35%.

(*a*) Shows low ultimate and high elastic limit usually found in material that has been punched or sheared. (*b*) The material is high carbon steel. (*c*) The material is rolled nickel steel (about 3% nickel), possessing great tensile strength and ductility. (*d*) The material is soft or rivet steel.

150. (*a*) What should be considered in surface examination of material? (*b*) State defects likely to be found in both steel and cast iron.

(*a*) The material should be examined for—

1. Color.
2. Defects due to casting or rolling.
3. Hardness.

(*b*) The surface defects of steel are: Blow-holes and pipes; pits; cinder spots; stars; cracks; laps or laminations; seams; snakes and cobbles.

The surface defects of cast iron are: Swells, scales and blisters, cold shorts, etc.

151. What is (*a*) piping; (*b*) "burning;" (*c*) how do you inspect to discover them?

(*a*) A "pipe" is a cavity produced by the outside of an ingot cooling more rapidly than the inside. This defect usually occurs within conical lines in the upper third of the ingot.

(*b*) "Burning" occurs when a piece of steel is overheated.

(*c*) "Piping" is discovered in an ingot by cutting off the metal near the upper part. If an ingot having pipes is rolled into shapes the defect will show in cavities in the rolled material.

"Burning" is indicated by small cup-like holes. A burnt rivet throws off sparks upon being withdrawn from the fire.

152. (*a*) What are the essential points to be inspected about riveting; (*b*) How are loose rivets made to seem tight under a hammer test; (*c*) how would you know deceit was practiced?

(*a*) 1. The rivet metal must be tested for tensile strength, bending and ductility.

2. The holes must match correctly.

3. Rivets must be heated correctly.

4. Rivets must be driven to fill holes completely, with full concentric heads. All rivets must be tight.

(*b*) Loose rivets are sometimes made to appear tight by going round the edges with caulking-tool. Rivets are also made to appear tight by placing the "snap" sideways upon the rivet and striking it a few heavy blows with a sledge.

(*c*) If a caulking-tool has been used, the marks left by the tool will be apparent upon close examination. If the "snap" has been hit sideways it will cut a ridge in the plate and force the metal against the head.

153. State all the details to be inspected in the case of a finished girder for a plate girder bridge span.

The Inspector should see that—

1. The correct shapes and plates are used.

2. That stiffeners bear tightly on top and bottom flange angles.

3. The girder must be straight and true and the web must not project above the flange angles.

4. The spacing and number of field holes must agree with those shown on plans.

5. The length and all other dimensions of the girder must be correct.

6. Web splices and all abutting surfaces must be made to close tightly.

154. State all the details to be inspected in the case of a finished post for a pin-connected span.

1. That correct shapes and plates are used and that all dimensions are correct.

2. All rivets must be tight, and abutting surfaces must be made to close tightly. All parts must be free from twists and bends.

3. The pin holes must be bored exactly perpendicular to the vertical plane passing through the center of the member, and the distance from center to center of pin holes must be correct.

155. How would you check the field connections of (*a*) a skewed portal; (*b*) a lattice girder of which members are shipped separately?

(*a*) Try the connections on a templet.

(*b*) Assemble the girder in the shop before shipping.

156. What are the important points to be inspected about painting to secure thorough preservation from rust?

1. All material must be thoroughly scraped and cleaned with a steel brush before applying the paint.

2. All surfaces which are to be in contact must have a coat of paint applied before riveting.

3. The composition of the paint must comply with the specifications.

4. The paint must be well worked into all joints and open spaces.

5. Pins, bored pin holes, friction rollers and screw threads must be coated with white lead and tallow before being shipped from the shop.

157. In first-class work what variations are allowable in the following: (*a*) Pin and pinhole connection; (*b*) riveted connection; (*c*) length of stringer; (*d*) length of floor beam; (*e*) length of eye-bar; how should the last be measured?

(*a*) The allowable variation may be $\frac{1}{50}$ in. for pins less than $4\frac{1}{2}$ in. diameter, and $\frac{1}{32}$ in. for pins of a larger diameter.

(*b*) Holes must match almost exactly.

(*c*) Stringer may be $\frac{1}{16}$ in. short.

(*d*) Floor beam fitting in between posts may be $\frac{1}{16}$ short.

(*e*) Eye-bars may vary from the calculated lengths $\frac{1}{16}$ in. for each 25 ft. of their length.

The centers of the holes are first marked on the eye-bars and this distance is measured. After the holes are bored the distances between the tops of the holes and also between the bottoms are measured. The average of these lengths will give the distance between the centers of holes.

158. In the storing of structural steel on the ground prior to erection, what general rules should be observed?

The material must be carefully piled up on skids or timber so as not to touch the ground. All members should be so placed that they will shed rain-water. Material should be so placed as to require the least amount of handling when needed for erection and cause as little interference with traffic as possible.

159. Describe an erection sheet and state how you would use it.

An erection sheet is an outline diagram of a structure giving the relative positions of all members and indicating each member by its shop mark. When a member has been received on the ground it should be checked on the erection diagram.

160. (*a*) What is falsework? (*b*) What is it used for in bridge work? (*c*) Is falsework employed in the erection of all bridges? (*d*) Where falsework is being used and a considerable part of the bridge has been assembled on it, what particular feature of the falsework would you carefully inspect, and how often would you make the inspection?

(*a*) and (*b*) Falsework consists of timber or steel columns, trestles, etc., built under a bridge or other structure to support the same during erection and until it has been connected up and is able to support itself.

(*c*) Falsework is not necessary in the construction of cantilever bridges, or of plate girder and short truss bridges.

(*d*) Examine the wedging and see whether the falseworks have settled below the correct position of the truss. This should be examined every day.

161. What are the essential points to be inspected about the following processes: (*a*) Assembling; (*b*) punching?

(*a*) In assembling, the inspector must see that the correct sizes, shapes and thicknesses of metal are put together, that the holes match, and that the correct sizes of holes are used.

(*b*) In punching the inspector must examine the punch-dies to see that the edges of same are sharp and unbroken, and that the difference between the upper and lower die does not exceed $\frac{1}{16}$ in.; also, that the holes are punched exactly at the points marked.

162. Describe in detail the usual order of assembling the parts of a "through truss" riveted highway bridge.

Chords are first laid down on falseworks with wedging at the panel points to allow for raising or lowering during assembling;

the posts and diagonals of a panel are then put in place and lastly the top chord; the best way is to start at the center of the truss and work towards each end.

163. What must be particularly noted in assembling connections regarding the surfaces which become inaccessible after assembly?

Surfaces which are inacessible after assembling must be given two coats of paint before the parts are assembled.

164. State what you would do, if in assembling you find a member bent or otherwise injured?

Send the member to the straightening machines and have the defect remedied.

165. How should large steel pins be driven in connections and how should they be protected?

Large pins are driven into place by means of jacks. They are protected during driving by pilot heads and nuts.

166. What is the object of each of the following tests of wrought steel: (*a*) Cold bend; (*b*) hot bend; (*c*) quench and bend; (*d*) drift?

(*a*) To test cold-shortness or the presence of phosphorus.
(*b*) To test hot-shortness (containing sulphur, arsenic, etc.).
(*c*) To see whether it will stand hardening.
(*d*) Made to see how much a rivet hole can be enlarged under different conditions without fracturing the material.

167. In high buildings with iron or steel columns how should the abutting faces on flanges of superimposed columns be finished? Should the use of lead or shims of iron be allowed between such surfaces when the pressures are heavy?

All cast-iron, wrought-iron and steel columns should have their bearings faced smooth and at right angles to the axis of the column, and when one column rests upon another they should be securely fastened together without lead or iron shims between them.

168. What is the law regarding open columns?

They must have their ends covered with bed-plates.

169. How should iron cribbing be treated before being laid?

When used below high water, it should be entirely coated with coal tar or paraffine varnish before being placed. Iron footings for columns must be similarly treated if below water level.

170. To what points should you give attention in erecting iron-work in buildings?

See that the parts are of the required sizes and properly connected by a sufficient number of rivets; that all the rivets are properly headed and fast; that the different parts are not excessively strained due to certain members being short or long. That the parts of columns are well centred.

171. How may beams be strengthened at supports?

They may be strengthened by struts or else by cushion rafters.

172. What is a cantilever and why is this construction used in large buildings?

A cantilever is a wooden or iron block or beam projecting from a wall or column to bear mouldings, balconies and the like. The principle is applied in the construction of bridges to support enormous weights. It is also used to enable a symmetrical spreading of the foundations in large buildings.

173. What factor of safety shall be allowed in computing the sizes of beams, girders or pieces taking transverse strains?

Factors of safety varying from 4 to 10 should be used, depending upon the materials and other conditions.

INSPECTOR OF REGULATING, GRADING AND PAVING.

174. Name the principal pavements used in city streets.

The principal pavements are:
Asphalt (sheet and block), stone block (cobble, Belgian and granite), wood block, brick, and macadam.

175. Describe the characteristics of a first-class pavement for use in the city.

A good pavement should be impervious, hard, durable, noiseless and clean. It should afford a good foothold for horses, be adapted to all grades, and all classes of traffic. It should be cheap and easy to repair.

176. State what you understand by the term "regulating."

Regulating in highway construction refers to the operation of fixing lines and grades for the guidance of the workmen, and to define the limits of the work.

177. What do you understand to be the difference between materials classified as rock and those classified as earth in paying for grading jobs? How is the classification determined?

In grading jobs, materials are usually classified as follows:
Earth Excavation—which includes clay, sand, loam, etc., or these materials intermixed with boulders measuring less than 1 cu. yd.
Loose Rock—which includes all stone and detached rock in masses less than 3 cu. yd; also, slate and other rock that can be quarried without blasting.
Solid rock, which includes all rock found in place in ledges and masses which can only be removed by blasting.

178. Describe the steps of construction of a first-class pavement and street to take the place of a common dirt road.

The road is first surveyed and cross-sectioned, profiles prepared and grades established.

The cross-section is planned, showing the dimensions and character of the pavement and foundation.

The road is staked out, grade stakes being set at centre, curbs, house lines and slopes, with depth of cut or fill indicated.

The excavation for both curb and roadway is then made to subgrade. The bottom is drained, flushed, tamped, freed of all poor material (which is replaced with good soil or sand), and brought to

an even surface parallel to the finished paving. The curbs should then be set.

Upon the subgrade a layer of concrete is spread for the foundation, having its top surface parallel to finished pavement.

Upon the concrete is spread a cushion layer of sand or a binder layer of asphalt and stone, depending upon the kind of covering to be used.

Upon this the final and finishing layer of blocks or asphalt is laid.

The construction of the sidewalks proceeds at the same time and in substantially the same order.

179. Where a high embankment is to be made in grading a street, state (*a*) whether it makes any difference how the material is distributed, and if so what the rule is. (*b*) Give your reasons.

(*a*) The best way is to spread the fill in horizontal layers from 9 to 18 in. deep, flush each layer with water and compact by rolling with a heavy roller.

The method ordinarily followed is to complete the construction of the embankment to a certain height by dumping over the end, leaving same for a time to settle, and then depositing a second layer in the same way, and so on.

(*b*) The first method is the best because it reduces settlement of the embankment to a minimum. Settling of the embankment is injurious to the pavement and may cause its entire destruction.

180. State fully and clearly everything to be done in preparing the ground surface for and laying a telford road, with macadam surface.

The surface of the roadbed must be graded uniformly to a depth of 18 in. below the finished surface, and compressed by rolling. On this is laid a course of large, irregular-shaped stones about 10 in. deep, 6 in. wide and 15 in. long. The broadest edge is placed on the earth bed, and the wedge-shaped spaces between the stones are filled with smaller pieces and chips of stones. The projecting corners of the large stones are broken off with hammers. On the surface of the telford foundation a 4-in. layer of broken stones (not greater than 2½ in. in their largest diameter) is laid, sprinkled and rolled; dry trap screenings are rolled into the interstices of the broken stone; the top 4-in. layer of broken stones is then laid, no stones being greater than 2 in. in their largest diameter; this is sprinkled and rolled, until brought to the true grade. A surface coat of screenings is then applied, thoroughly soaked by sprinkling and worked into the interstices of the top layer by rolling with a roller of not less than 4 000 lb. to the foot of width.

181. State the essential points of a first-class stone block pavement.

1. Quality of the stones.—They should not be too hard or capable of taking any polish, and should afford good foothold for horses.

2. Size.—Depth should be about 7 in., width not more than 4 in., and length 9 to 12 in. They should be well squared.

3. Foundation.—Should be constructed of hydraulic cement concrete, 4 to 9 in. thick, depending upon the character of the traffic.

4. Cushion course.—A ¾-in. layer of sand, clean, dry and free from pebbles, should be spread over the concrete.

5. Laying.—Should start at the sides and proceed toward the center and the whole row keyed tightly. Joints should be broken and as narrow as possible. Blocks must be well rammed and low blocks removed and properly replaced.

6. Blocks should be laid in parallel courses at right angles to axis of street.

7. Joints should be filled with paving pitch and gravel and a layer of sand should finally be spread over the blocks.

8. At intersections the blocks should be laid diagonally or as usually called in the "Herring-bone" fashion.

182. Is it detrimental, in your opinion, to pave stones of different depth in the same row in a pavement, and if so, why?

Yes. If the stones in the same row are not uniform in depth they are liable to settle unequally under traffic, causing hollows and ridges, and eventually destroying the pavement.

183. In what way is poor work done by pavers in selecting and placing paving blocks?

1. By not placing blocks of a uniform width and depth in the same row.

2. By not ramming the blocks to a firm bearing and even surface.

3. By not breaking joints properly.

4. By not pouring the required quantity of paving pitch into the joints.

184. What is meant by "back-ramming" and what is its object?

The operation of ramming newly-laid blocks often causes blocks which have been previously rammed to loosen up slightly. "Back-ramming" refers to the operation of bringing these blocks back to firm bearing.

185. Describe in your own language a perfect paving brick, considering (*a*) its form, finish and dimensions; (*b*) the materials of which it is composed and its physical condition.

(*a*) "Standard" paving-bricks are 2½ by 4 by 8 in. They should be annealed, non-porous, close in texture, have clean, sharp edges and be uniform in size and appearance.

(*b*) The clay employed in the manufacture of paving-brick must be rich in silica, free from lime, and able to withstand without fusing a red heat for a sufficient length of time to render the bricks hard, homogeneous and impervious to water.

The physical properties of a good paving-brick are:

1. It is not acted on by acids.
2. It does not absorb more than $\frac{1}{100}$ of its weight of water in 48 hours' immersion.
3. It is not susceptible to polish.
4. It is rough to the touch, resembling fine sandpaper.
5. To give a clear, ringing sound when struck with another.
6. When broken, to show a compact, uniform, close-grained structure, free from air-holes and pebbles. Marked laminations are bad defects.
7. Not to spall, chip, or scale when quickly struck on the edges.
8. Hard, but not brittle.

186. Describe the construction of a first-class brick pavement.

The bricks should be of the best quality paving-brick, annealed and 2½ in. x 4 in. x 8 in. in size.

The street should be excavated to subgrade, all objectionable material removed and replaced by firm soil or sand, and the bottom watered and rolled, so that it will be parallel to the finished surface.

Upon this layers of gravel and sand or concrete and sand are spread for foundation and cushion courses.

The bricks are laid on the prepared bed of sand. They should be laid on edge at right angles to the axis of the street and break joints by 3 in. or more. No broken bricks should be permitted, except at closing points.

Before closing they should be compressed by iron bars and then keyed by close-fitting bricks. After 25 or 30 ft. of paving are completed, the bricks should be rammed with 50-lb. rammers and all low bricks removed and properly replaced.

The joints are then filled with sand, cement or paving pitch, and a layer of ½ in. of dry sand spread over the entire surface.

187. State all the points to be observed in laying an asphalt pavement over an old cobblestone pavement.

The surface of old pavement should be thoroughly cleaned by sweeping with stiff brooms until all dirt, etc., has been removed from the surface and from the joints to a depth of about 1 in.

The surface is then evened up and brought parallel to the finished grade by excavation if necessary, all depressions being filled with binder or concrete. Upon the blocks thus prepared a binder course is laid consisting of paving-pitch and 1¼-in. broken stone, 1 gallon to the yard. The surface of the binder is made parallel to the finished surface. The stone used in the binder should be heated. The wearing surface of asphalt is then laid and rolled upon the binder to the required thickness, and covered with a thin coating of hydraulic cement.

188. (*a*) What are the principal requirements in relaying asphalt pavements? (*b*) In relaying block pavements?

(*a*) In relaying asphalt pavements the sub-grade must be brought to a true surface, well rammed and free from all objectionable matter.

The foundation course of blocks or concrete must be carefully laid and bonded with the adjoining portions of the old foundation. The binder is then put on. It should also be well bonded with the adjacent portion of the old binder. In joining the old work with the new, the old must be cleaned and stripped of disintegrated or loose portions and in the case of concrete thoroughly wetted.

The wearing surface is then laid and well tamped with hot irons where it joins the old work.

The new surface is thoroughly rolled until it presents a uniform appearance with the old.

(*b*) In relaying block pavements the surface at sub-grade, as well as the concrete foundation and cushion coat, should be brought true and well tamped, so that when the blocks are rammed they will be firm and present an even surface without ruts or depressions. Sand must be used to adjust sub-grade when necessary. The blocks should fit properly and not work loose, and must be well bonded into the old pavement. The joints are then filled with pitch and gravel and a layer of sand spread over the new work.

189. (*a*) In preparation of the surface of concrete to receive binder or of binder to receive a subsequent coat of asphalt, name two essential things to be guarded against. (*b*) State why.

(*a*) No water or moisture must be present on the surface of the concrete or binder.

The surface of the foundation should not be left too smooth, so that a good bond will be secured.

(*b*) When the hot asphalt is applied to a damp surface, the water is immediately turned into steam, which tries to escape

through the heated material. As soon as the pavement is subjected to traffic, the fissures formed by the steam appear on the surface, and the whole pavement quickly falls to pieces.

If the asphalt pavement is not well bonded with the foundation it tends to slip under the action of traffic and roll up into waves.

190. Which would you consider the best finish to leave on the surface of a concrete bed for an asphalt pavement, that it should be smooth or left rough? State your reasons.

A slightly rough surface is better than a perfectly smooth finish, because it gives a better bond between the asphalt pavement and the concrete foundation, and it also prevents the slipping of the asphalt surface on the foundation.

191. (*a*) What is the proper temperature at which asphalt should be brought on the work? (*b*) What effects are produced by its being either too hot or too cold. State each.

(*a*) 250° F.

(*b*) If the asphalt is overheated it is decomposed and loses its adhesive qualities.

If the asphalt becomes too cold on the work it hardens and cannot then be worked to the correct shape of the roadway.

192. State how you can tell whether the paving-pitch has been overheated or not. What is the result of overheating on its wearing qualities?

If paving-pitch is overheated it becomes coked, in which condition it is brittle and useless.

193. State as nearly as you can the causes for (*a*) the formation of long cracks across an asphalt street. (*b*) The shoving up into waves. (*c*) The breaking up or wear in spots.

(*a*) Due to unequal contraction of surface asphalt and of binder in very cold weather; also to irregular settlement of foundation.

(*b*) Under extreme heat the asphalt is liable to become so soft that it will roll, or creep under traffic and present a wavy appearance.

(*c*) Usually due to the disintegrating effects of standing water.

Also due to carelessness in relaying pavement after it has been taken up. Fires on the streets will also cause bad spots in the asphalt.

194. (*a*) How may water affect an asphalt pavement after it is laid, and where is this effect most likely to occur? (*b*) State what is done to prevent this?

(*a*) Water, if permitted to remain upon the pavement, causes the asphalt to disintegrate. This effect is most likely to occur in the gutters.

(*b*) The gutters for a width of 12 in. next to curb must be coated with hot, pure asphalt, and smoothed with hot smoothing irons in order to saturate the pavement with an excess of asphalt; or the gutters may be constructed of paving-blocks well bonded into the asphalt.

195. (*a*) What is the least grade that is desirable for the gutters of a street? (*b*) Where the grade between two intersections is too flat, by what expedient may better grades be obtained without disturbing the cross-streets?

(*a*) The least gutter grade is about one-half per cent.

(*b*) Accommodation summits are put at the center of the main streets, thus giving them a slight fall towards the crossings and causing the water to flow in both directions from the summit.

196. What are the minimum and maximum allowable grades (*a*) for granite block pavement? (*b*) For asphalt pavement? (*c*) Wood? (*d*) Macadam?

	Minimum Grade.	Maximum Grade.
(*a*) Granite block........	1.5%	10% and over
(*b*) Asphalt	0.5%	$2\frac{1}{2}$%
(*c*) Wood................	0.7%	5%
(*d*) Macadam............	1.0%	5%

Grades outside of these limits are, however, occasionally employed.

INSPECTOR OF SEWERS.

197. What are the essential requirements in a well-constructed sewer?

A well-constructed sewer—

1. Must have a solid foundation.
2. Must be laid to true line and grade.
3. Must have a velocity of flow sufficient to prevent settlement, but not high enough to cause "scour."
4. Must be constructed water-tight.
5. Must have manholes at summits and valleys and at all changes of direction, and enough lamp-holes to permit thorough examination.
6. Must be laid below frost line and low enough to take the waste from all houses along its route.
7. The outlet must be carried to a point where it will not cause a nuisance, or be a menace to health.

198. Describe (*a*) your inspection of bricks delivered on the work for a sewer; and (*b*) the only right way of laying the same to insure tight work.

(*a*) The bricks must have the proper color, and be free from cracks or flaws. No bats are to be used. The bricks must be culled upon delivery on the ground; the inspector should immediately send samples, selected at random, to the laboratory for such tests as he cannot make on the ground. A brick should not absorb more than about one-tenth of its weight of water, should emit a clear, ringing sound when struck a sharp blow, and when broken should show a compact, uniform structure, hard and somewhat glassy, and be free from air bubbles, cracks, cavities and lumps.

(*b*) Every brick is required to be laid in full mortar joints, on bottom, sides and ends, which for each brick is to be performed in one operation.

199. Outline specifications for building a brick sewer.

The bricks shall be of best quality, hard-burned, free from cracks, and have true, even faces.

They must be thoroughly wet before laying.

Each brick must be laid in full mortar joints on bottom, sides and ends, which must be performed in one operation.

Hydraulic cement mortar should be used.

No mortar is to be worked in after brick is laid.

Joints should not exceed $\frac{3}{8}$ in. in thickness.

Brickwork should be properly bonded and arches keyed.

Cement and sand should be of proper quality and properly mixed.

The mortar should be used right after mixing; no mortar which has begun to set should be used.

No work should be done in freezing weather.

Every second course should be laid with a line.

The foundation must be firm and unyielding.

Centres must be of proper form and dimensions and proper care observed in "striking" same.

200. What is the best bond for brick sewers?

The best bond is the rowlock bond, which consists of concentric rings, each longitudinal course breaks joints with the adjacent courses and with the rings above and below. All bricks are laid as stretchers.

201. Where are headers used in a circular brick sewer and why are they so used?

Most specifications prohibit the use of headers in brick sewers, especially in the upper or arched portion. In large brick sewers, however, where three or more rings of brick are used, the rings are laid alternately as headers and stretchers with such modifications as are necessary to secure a perfect bond.

202. Describe the proper method of keying a brick arch.

The usual specification is as follows:

In keying the arch no headers are to be used. The inner and outer courses of stretchers are to be carried over and keyed separately, and each course in the crown of the arch is to be thoroughly grouted.

203. How and when should centres be struck?

Centres should not be struck before the mortar has had ample time to set. They should then be struck so as to bring the pressure uniformly upon the arch.

204. What are the rules governing the insertion of spurs in brick sewers, as to location, direction, etc.?

Spurs are usually spaced about 12 ft. 6 in. along the sewer pointing alternately towards house lines or opposite sides of street; this gives one spur for each 25-ft. front lot. The spurs must enter near the top of the sewer section and point in the direction of the flow.

205. Describe alteration in line of a large brick sewer and method of caring for the flow meanwhile.

The sewer is first built along the new line, and when ready to join on to the old work a bulkhead of brick or cement bags is built at the points where the change of line begins and ends, the arch between the points having already been removed. A temporary flume (or flumes) of sufficient size to carry the greatest flow, having the ends built into the bulkheads, is suspended or supported in the line of the old sewer, and far enough above the old invert to permit the construction of the new invert at the points of connection. The old invert is now removed, the new work built and the connections made, after which the bulkhead and flume are removed and the flow turned into the new sewer.

206. Outline specification for back-filling subway near adjacent sewer.

Filling should consist of sand, gravel or good, clean earth free from stones over 8 in. in diameter and not containing more than one portion of stone to three of earth. It should be deposited in layers not more than 9 in. thick, watered and packed by rammers weighing not less than 30 lb., and in such manner that no unbalanced pressure can be thrown upon subway or sewer. Filling must be carefully packed and rammed about sewer, using special tools. No filling should be made with frozen earth. Sheeting should be carefully withdrawn as fast as filling progresses or may be left in place.

207. In building a large sewer where quicksand is encountered (*a*) how would you proceed to get sound work? (*b*) Under what conditions does quicksand of itself make a good foundation?

(*a*) In excavating for the foundation the width of the trench should be 2 to 4 ft. more than is required for the masonry. The sides should be very strongly braced by sheeting. Double wall linings should be used and provided with a cutting edge at the bottom, strongly braced between walls and filled with clay and sand. The excavation should proceed under the cutting edge, leaving a core at the center which is gradually removed with the sinking of the lining until a good foundation is secured. The excavation can be facilitated by forcing cement grout into the quicksand, solidifying the mass, or freezing the mass by the usual freezing process. When the proper depth is reached piles may be driven with butt end down into the underlying strata to solid bearing and the sewer built on the piles in the usual manner.

(*b*) When quicksand is so confined and drained as to prevent flowing or displacement of same, it will make a safe foundation.

208. How frequently should catch-basins be placed along a street, and what rule governs this? How frequently should manholes be placed?

Catch-basins should be placed at all low points in the street where considerable water is apt to collect. On long grades catch-basins are placed at every street intersection where the grades permit.

Manholes should be placed every 100 ft. for small sewers; for large sewers this distance may be from 200 to 500 ft., depending upon their size. They should be frequent enough to permit cleaning and afford proper ventilation for the sewers.

209. What is a flush-tank and what are its uses?

A flush-tank is a device for periodically flushing a sewer by automatically and rapidly discharging a large quantity of water into it. It is usually placed at dead ends of sewers, where material is apt to collect.

It is an essential feature of the separate system in which no storm water is permitted to reach the sewers. The water for operating the tank is supplied by the regular mains.

210. It is necessary to rebuild 100 ft. of a 48-in. brick sewer with considerable flow of water through it; describe completely the operation.

The top of the sewer is first removed. To take the flow during construction, a flume is built at the bottom of the sewer starting a little beyond each side of the 100-ft. length which is to be rebuilt. The sides and bottom of the sewer are now removed, the flume being firmly supported at all stages of the operation. The construction of new foundation and the lower half of the sewer is then proceeded with; after the brickwork has set the flume is removed so as to divert the regular flow into the new invert, and the upper half of the sewer is completed.

211. Describe the rules that must now be observed in laying pipe sewers.

The pipe must be laid true to grade and line, and each length properly bedded. A recess must be cut in the bottom of the trench to receive the socket of the pipe.

The spigot-end of each pipe must be properly entered and sent home into the socket of the adjoining pipe.

The gasket of hemp or oakum must be properly used. The socket should not be filled with it to the exclusion of the mortar.

The joints must be carefully filled with cement mortar all around.

Spurs must be closed with suitable stoppers if not to be used immediately.

The backfilling must be carefully done; no stones should be used for filling within one foot of the pipe, and the material must be tamped with suitable tampers to insure compactness.

212. Describe in detail the method of laying a 30-in. cast-iron pipe.

The trench should be dug 4½ ft. wide, and at joints deep enough to permit access for caulking. Two blocks and four wedges are then laid on line a little below grade of pipes. The pipes are rolled over the trench, raised by a derrick and lowered into position, bells facing up hill. They are then raised to true grade by means of the wedges; the spigots should be entered well into the bell and be concentric with same. The gasket of oakum is driven into the annular opening, leaving about 3 in. for the lead. The lead is run in one operation so as to leave a projecting bead which is driven in by caulking, making perfectly tight joints.

213. Suppose the top of the grade stake set at one end of a 25-ft. length of sewer was 13 ft. 3 in. above grade, and at the other end 11 ft. 7 in. above grade; how would you fix grade line?

Upon the stake whose top is 13 ft. 3 in. above grade, mark a point 2 ft. 3 in. below top; also mark a point 7 in. below the top of the other stake. A string stretched taut between the points thus marked will be parallel to, and 11 ft. above grade. Points on grade are readily obtained by measuring down 11 ft. from the string.

214. Describe a good job of tamping earth around a sewer, giving best arrangement of men and other requirements.

The trench should be filled with layers not exceeding 4 in. thick in the loose, and the earth used is not to be dumped in piles, but is to be spread evenly and compressed by iron tampers. The number of men using tamping irons should be in the proportion of four tampers to one shoveller. In case of pipe sewers, special precautions are necessary. The earth must be carefully laid in, tamped, and solidly rammed down, under and around the pipes, with proper tools made for this purpose.

215. How soon can filling-in be done about a pipe sewer? What governs this?

The back-filling should not be commenced in the case of a pipe sewer until the cement joints have hardened sufficiently.

216. How much clearance in a trench should be allowed each side of a sewer to obtain good work?

One foot.

217. Under what conditions would you think it desirable to leave the sheeting in a trench and why?

In soft ground the lower course of sheeting should not be removed after the arch of the sewer has been built, as the arch is liable to crack if uneven settlement of the material above takes place.

218. Of what are soil pipes constructed and where trapped?

All mains, soil, waste or vent pipes must be constructed of iron, steel or brass. Soil pipes when connected with any fixtures must be trapped before entering the sewer and the trap so arranged that it can be reached for cleaning and be protected from frost.

219. Why should traps be connected with vent pipes?

To carry off any gases collecting in the traps, and insure proper ventilation. Otherwise the gases might force the seal in the traps and work back into the house.

220. What kind of traps may be used? What are their sizes and how set?

Only water-seal traps may be used with a seal of at least 1½ in. They must be well supported and set true with regard to their water level. The discharge from any fixture must not pass through more than one trap before reaching the house drain.

221. When shall sewer connections be made?

The connections should be made before the walls are carried above the foundations.

222. What do you understand a fresh-air inlet to be for?

It is used to furnish fresh air to the house drain just inside the house trap. It should extend to the surface or into a box and have a return bend.

MANUAL OF EXAMINATIONS

FOR

ENGINEERING POSITIONS

IN THE

SERVICE OF THE CITY OF NEW YORK

QUESTIONS AND ANSWERS
IN THREE VOLUMES

VOL. I. AXEMAN, CHAINMAN AND RODMAN, LEVELER, TRANSITMAN AND COMPUTER
VOL. II. ASSISTANT ENGINEER
VOL. III. DRAFTSMAN AND INSPECTOR

APPENDIX

EXAMINATIONS FOR CIVIL ENGINEERING POSITIONS
IN
FEDERAL, STATE AND MUNICIPAL SERVICE OUTSIDE OF THE CITY OF NEW YORK (INCLUDING PANAMA CANAL AND UNITED STATES NAVY)

INDEX

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GENERAL APPENDIX I.

CIVIL SERVICE OF THE UNITED STATES—GENERAL INFORMATION AND PREVIOUS EXAMINATION PAPERS.

INTRODUCTORY.

In order to increase the range of usefulness of the "Manual of Examinations for Civil Engineering Positions in the City of New York" and answer the many queries that have come to the publishers in reference to Civil Service outside the city, the following appendix is introduced. The appendix gives the examination requirements, previous examination papers, and number of positions open wherever obtainable. The examination papers include the Federal Service, United States Navy, New York State, Boston, Chicago, and other important cities. It is hoped that the collection of previous examination questions will prove useful to instructors and students in Technical Schools and to Civil Service Examiners, as well as to applicants for Civil Service positions.

Interleaving has been introduced to provide space for notes, sketches and additions.

The publishers will appreciate the receipt of Examination Papers, etc., not included in this compilation, from Civil Service Authorities and others for use in future editions.

OPPORTUNITIES FOR ENGINEERING GRADUATES IN THE SERVICE OF THE FEDERAL GOVERNMENT.*

The civil service of the government is a vast organization, including more than a quarter of a million people.

There are about 2 600 opportunities for engineering graduates in the government service, excluding West Point, the Isthmian Canal, and positions paying less than $700 per annum. For 46 per cent. of these positions the pay is between $700 and $1 400 per year; for about 32 per cent., from $1 500 to $1 900; for 18 per cent., $2 000 to $2 900; for three per cent., $3 000 to $3 900; and for nearly one per cent., $4 000 or over. These figures are for salary only, they do not include allowances for expenses, subsistence and quarters furnished, etc., which are received by many.

There are nearly 700 opportunities under the Chief of Engineers of the army for engineering graduates. This force includes 180 assistant engineers or superintendents, 150 junior engineers, and 70 draftsmen. The lake survey is a part of this group of 700.

There are more than 500 opportunities in connection with navy yards and naval stations. This includes 40 civil engineers and constructors, and nearly 400 draftsmen.

In the engineering force of the Reclamation Service, under the Geological Survey, there are 360 engineers. This service is growing very rapidly and will probably continue to do so for several years. Hence, it furnishes the best chance in the government service for the rapid advancement of unusually able men, with the possible exception of the Panama Canal work.

Three hundred patent examiners are employed in the Patent Office.

In the Coast and Geodetic Survey there are 130 opportunities for engineering graduates; 90 in the field force, 20 as draftsmen, and 20 as computers.

There are 130 opportunities under the General Land Office.

The remaining 500 opportunities are scattered through the service. The largest groups are in the Topographic Branch of the Geological Survey, in the Revenue Cutter Service in charge of marine engines, under the Supervising Architect as superintendent, and in the engineer department of the District of Columbia.

New appointments are being made at the rate of about 200 per year to repair the waste in the force of 2 600, and to produce the steady expansion which is normally in progress.

Nearly all of the 2 600 positions are in the classified service, to which entrance is guarded by the Civil Service Commission and

* From Vol. XIII, Proc. Soc. for the Promotion of Engineering Education.

from whom full information concerning the examinations may be obtained.

For many examinations, especially examinations requiring technical qualifications, the Civil Service Commission distributes special printed announcements about one month in advance of the examination. Any professor of engineering may have all such announcements, covering specified lines, sent to him regularly merely by making a request in writing to that effect. The student, or graduate, may also, as an individual, apply for these announcements and receive them as they appear.

Do not write for an application blank for an examination which has not yet been officially announced.

By using the manual and annual report and the special announcements of examinations, the professor of engineering may keep in close touch with nearly all the opportunities for appointment of his graduates to the classified civil service, except the following two large classes.

First, the five hundred positions which have been referred to in connection with the navy yards and naval stations are filled by examinations held under the direction of the Navy Department, not the Civil Service Commission. Many of these examinations are advertised and held only in the locality in which the appointment is to be made. Information in regard to these examinations must be obtained at the Navy Department at Washington, or from the officers having local charge of the work.

Second, there are two methods of entrance to the position of junior engineer under the Chief of Engineers; namely, by a civil service examination, known as the "civil engineer, departmental service" examination, and by promotion from lower grades in the service, under the Chief of Engineers, such, for example, as inspector, recorder, transitman, levelman, rodman, or chainman. Appointments are made to these lower grades from registers of eligibles established at various points by local boards of civil service examiners, without examination. Any employee may be promoted from one of these lower grades to the grade of junior engineer on the recommendation of his employing officer, provided he passes the appropriate examination held under the direction of the Civil Service Commission. If he holds a diploma of graduation in an engineering course from an approved technical school he may, after one year's service, be so promoted without examination. This is the class to which your attention is especially called. For more complete data apply to the Chief of Engineers for the circular known as "information concerning positions under the engineer department at large."

Information in regard to rates of promotion, prospects of promotion, character of service required, and the conditions of service, must, in general, be obtained from the different bureaus or depart-

ments concerned in much the same way that it is obtained in regard to positions outside the government service; that is, by correspondence or personal acquaintance with those in charge or with the employees. Such information cannot, except to a limited extent, be obtained from the Civil Service Commission.

Promotions in the government service are made on merit. Merit is, as a rule, ascertained in much the same manner as in any large organization, by observations of the employee's work by his official superiors. It is placed on record by the recommendations of those superiors.

In the Reclamation Service, such recommendations are all placed twice a year in the hands of a committee of three men of high rank in the service who have a wide acquaintance with the personnel. This committee virtually decides what promotions shall be made, subject, of course, to approval. A similar system is in force in the Geological Survey as a whole.

Under the Chief of Engineers, promotions from junior engineer to assistant engineer depend upon recommendations by the official superiors, but are also subject to two conditions. The candidate must, at some time, have passed the civil engineer examination before the Civil Service Commission, and he must possess the professional qualifications that are required for full membership in the American Society of Civil Engineers. In general, an assistant engineer is selected from among the junior engineers in the district in which he is to serve. That is, the civilian employees in general stay in a given district on the work with which they are familiar, though the officers of the Corps of Engineers, under whom they serve, are periodically transferred from station to station.

As a rule, any attempt on the part of a government employee to bring political influence to bear to secure a promotion is interpreted as a confession on his part that he does not feel that he has sufficient merit to warrant promotion. The confession is apt to be taken at face value. Such confessions are rare.

INFORMATION RELATIVE TO EMPLOYMENT IN THE PHILIPPINE CIVIL SERVICE.*

OPPORTUNITIES.—The civil service of the Philippine Islands offers excellent opportunities to qualified persons, both in the matter of salary and promotion. Under the operation of the civil-service law promotions may be made on the basis of merit from the lowest to the highest positions, and the records of that service indicate that qualified appointees have been rapidly advanced.

AGE LIMITS.—The age limits for the service are 18 to 40 years unless otherwise expressly stated.

* Extract from Rules of U. S. C. S. Comm.

PHOTOGRAPHS AND MEDICAL EXAMINATION REQUIRED.—Each applicant for the Philippine service will be required to submit to the examiner, on the day he is examined, a recent photograph, taken not more than three years ago, of himself, which will be filed with his examination papers as a means of identification in case he receives appointment. An unmounted photograph is preferred. The date, place, and kind of examination, the examination number, the competitor's name, and the year in which the photograph was taken should be indicated on the photograph.

The medical certificate in Form 2 must be filled in by some medical officer in the service of the United States. Special arrangements have been made with pension examining boards throughout the country to give such examination for a fee of $2, to be paid by the applicant. If such boards can not be conveniently visited, applicants should appear before medical officers of the Army, Navy, Indian Service, or Public Health and Marine-Hospital Service.

The medical officer should indicate his rank or official designation on such certificate.

TRANSFERS.—Under a recent amendment to the Federal civil-service rules, employees who have regularly served for three years in the Philippine civil service are eligible for transfer to similar positions in the Federal service.

CLIMATE.—The climate is good, and nearly all the employees are in excellent health. There is continuous warm weather in the Philippines, but the heat is not intense, and the general health of American civilians who take reasonable care of themselves is good. During the greater part of the year Americans suffer less from the heat than during the summer months in many parts of the United States. From April to July is the hottest period. From July to October there are frequent rains which cool the atmosphere, and from about the middle of November to the middle of March the weather is, as a rule, clear and pleasant. The nights during this period are cool; in fact, the nights are generally pleasant during the whole of the year, with the exception of possibly two or three months. It may also be stated that China and Japan are near at hand and are favorite places to visit during vacations. Within twelve hours' travel of Manila, in the province of Benguet, where it is understood the summer capital is to be located, the climate is cool, and as the province is convenient and easily accessible it affords an excellent place at which to seek recuperation.

CLOTHING.—Americans usually dress in white drill suits. Those who go to the Philippines will find it to their financial advantage to wait until they reach Manila before purchasing any clothing for use in that climate. Serviceable white cotton drill suits are made to order in Manila for about $3 each. Heavier clothing, adapted to the climate at times, can also be purchased at very reasonable prices.

Medical Attendance.—At present medical attendance is furnished to employees in Manila without cost. A civil hospital has been established in Manila, to the wards of which civil-service employees are admitted at a uniform charge of $1 a day, with medical and surgical attendance, medical supplies, nursing, and food included. Those who desire private rooms are required to pay from $10 to $20 a week.

Cost of Living.—Those who live outside of Manila can live fairly well for $30 or less a month. In Manila the cost to employees is determined largely by the manner of living. Many who rent rooms and live in "messes" keep their living expenses in the neighborhood of $35 to $40 a month. The better hotels charge about $40 to $50 a month, while the best hotels are higher in their rates. A civil commissary has been established, the advantages of which are available to civil-service employees in the provinces, but not in Manila. The large number of dwellings now being erected warrants the prediction of a material decrease in rents during the year. An electric street railway throughout the entire city of Manila is nearing completion. This will do away with the expense of cab transportation. It will also materially reduce rents by permitting the population to scatter over a wider area, and will make life pleasanter and cooler and cost of living cheaper.

Leave of Absence.—After at least two years' continuous, faithful, and satisfactory service, the civil governor or proper head of a department shall, subject to the necessities of the public service, and upon proper application therefor, grant each regularly and permanently appointed officer or employee in the civil service, insular or provincial, or of the city of Manila, except as hereinafter provided, accrued leave of absence with full pay, inclusive of Sundays and of days declared public holidays by law or Executive order, for each year of service in accordance with the following schedule: An employee receiving an annual salary of less than $600 shall be granted twenty days' leave; an employee receiving an annual salary of from $600 to $900 with board and quarters, and an officer or employee receiving an annual salary of $900 or more, but less than $1 800, shall be granted thirty days' leave; an officer or employee receiving an annual salary of $1 800 or more shall be granted thirty-five days' leave. Leave shall accrue while an officer or employee is on duly authorized leave of absence with pay. In addition to the leave mentioned, an employee receiving less than $1 000 a year may be granted 21 days' vacation leave, and an employee receiving $1 000 a year or more may be granted 28 days' vacation leave during each calendar year. This vacation leave is in lieu of any leave of absence on account of sickness.

Transportation.—A person residing in the United States who is appointed to the Philippine civil service may pay his traveling

expenses from the place of his residence in the United States to Manila: *Provided,* That if any part of his traveling expenses is borne by the government of the Philippine Islands, 10 per cent. of his monthly salary shall be retained until the amount retained is equal to the amount borne by the government: *And provided further,* That if he shall come by the route and steamer directed, his actual and necessary traveling expenses shall be refunded to him at the expiration of two years' satisfactory service in the Philippines.

He shall be allowed half salary from the date of embarkation and full salary from the date of his arrival in the islands: *Provided,* That he proceed directly to the islands; otherwise he shall be allowed half salary for such time only as is ordinarily required to perform the journey by the route directed: *And provided further,* That such half salary shall not be paid until after the expiration of two years of satisfactory service in the Philippines.

A person residing in the United States accepting an appointment to a position in the civil service of the government of the Philippine Islands shall, before receiving such appointment, execute a contract and deliver it to the chief of the Bureau of Insular Affairs, War Department, wherein the appointee shall stipulate that he will remain in the service of the government of the Philippine Islands for at least two years, unless released by the civil governor or proper head of a department. A breach of the conditions provided in the contract or a removal for cause shall require the proper officer to withhold payment of all salary and traveling expenses due to the person employed and who has violated the conditions of his contract or been removed for cause, and shall debar such person from ever entering again the public service of the Philippine government in any of its branches. In such case an action shall lie for the recovery of the amount expended by the Government in bringing the employee to the Philippine Islands.

No arrangements have been made for holding examinations for ordinary clerical positions in the post-office, custom-house, and internal-revenue services and trades positions in the Philippines. Such positions are usually filled by the appointment of Filipinos. Application should be made to the Philippine civil-service board at Manila, P. I., for information concerning appointment to these positions.

INFORMATION CONCERNING CONDITIONS OF EMPLOYMENT IN THE ISTHMIAN CANAL SERVICE.

For the further information of applicants and others, the following statement is published relative to conditions of employment on the Isthmus of Panama under civil service rules by the Isthmian Canal Commission.

General Conditions on the Isthmus of Panama.—Representatives of the Civil Service Commission who have recently returned from Panama report that conditions have greatly improved on the Isthmus. The health of the employees is excellent. On April 11, 1906, less than two per cent. of the American employees were on the sick list. While there have been some cases of yellow fever since the Americans occupied the Isthmus, there has not been a single case since last November, which is due to the sanitary measures taken by the authorities. Substantial meals are furnished in the hotels erected for employees at 30 cents a meal, and comfortable quarters have been erected and are in course of erection for married men and their families and for bachelors. As higher salaries are paid than in the United States, it is practicable for employees to save a large proportion of their salaries. Employees on the Isthmus freely express their appreciation of the work done by the Government in providing for their material welfare, and there is a spirit of coöperation and contentment throughout the service.

The winter months on the Isthmus are, as a rule, clear and pleasant. During this period the nights are cool, which is also true of the nights during the summer months. While there is continuous warm weather, the heat is not intense. The quarters provided for employees are in cool places near the seacoast, or on the higher elevations, and it is believed that Americans on the Isthmus suffer less from heat than they do during the summer months in many parts of the United States.

Employees Whose Salaries are Fixed on a Monthly or Annual Basis.—The salaries of such employees begin upon the date of embarkation at port of departure from the United States, but no payment on account thereof shall be made until after thirty days' service on the Isthmus. They will be required to pay all expenses of the journey to the port of departure, which expenses will not be refunded, but they will be granted free transportation from that port to the point of destination, which will include meals on the steamer. Where practicable and in the best interests of the service they will be provided with such quarters on the Isthmus as may be available from time to time, and if such quarters are not available they will be granted, in lieu thereof, a sum, payable monthly, equal to 15 per cent. of their monthly compensation.

They may be granted, in the discretion of the head of the department in which employed, leave of absence at the rate of six weeks for every twelve months of service rendered, such leave to be cumulative for a period of two years and to be granted at any time after eight months' service in the discretion of the head of the department in which employed. If such leave is granted, they will be entitled to the Government rate of $20 each way on the steamers of the Panama Railroad and Steamship Company operating between New

York and Colon. This grant of a leave of absence is not to be considered a vested right, but is made to promote the welfare and interests of the service, and compensation for the period of their leave will not be paid until after their return to duty.

In the event of illness an employee may be granted, upon the certificate of an authorized physician of the health department in the Canal Zone of his disability for work, sick leave with pay, in addition to such other leave of absence as may be granted to him, such sick leave with pay continuing during disability not to exceed thirty days in any calendar year for an employee appointed in the United States whose salary is fixed on a monthly or annual basis, and not to exceed fifteen days in any calendar year for an employee appointed on the Isthmus whose salary is fixed in like manner. Such leave of absence on account of illness shall not be cumulative.

Employees whose salaries are fixed on a monthly or annual basis will receive no extra pay for overtime work required of them.

MEDICAL ATTENDANCE.—Free medical and hospital attendance in case of illness is provided.

RETURN TRANSPORTATION.—Free transportation is provided to a port of the United States upon the termination, by or at the instance of the Isthmian Canal Commission, of satisfactory service, the character and length of such service to be determined by the head of the department in which employed.

TRANSPORTATION OF FAMILIES.—Members of the immediate families of employees will, upon request, when the exigencies of the steamship service permit, be granted the Government rate of $20 between New York and Colon. No charge will be made for children under 6 years of age, and half rates will be charged for children between the ages of 6 and 12 years. Employees will not be permitted to take their families to the Isthmus until they have gone there first and secured quarters for them.

ASSIGNMENT OF DUTIES.—The assignment of duties is vested in the head of the department in which employed, and employees are expected to perform such duties as may be assigned them by competent authority. Services must be satisfactory to the head of such department.

Each applicant for the Isthmian Canal Service will be required to submit to the examiner, on the day he is examined, a photograph of himself, taken within three years, which will be filed with his examination papers as a means of identification in case he receives appointment. An unmounted photograph is preferred. The date, place, and kind of examination, the examination number, the competitor's name, and the year in which the photograph was taken should be indicated on the photograph. The medical certificate in the application is also required.

No person will be appointed for service on the Isthmus who is

not physically sound and in good health. Persons examined for positions on the Isthmus will not be eligible, as the result of such examination, to positions in the United States or Philippine services. Persons appointed will be expected to proceed promptly to the Isthmus of Panama.

Eligibles selected for appointment in this service will be subjected to rigid scrutiny and may be physically reëxamined upon reaching the port of embarkation for the Isthmus, and will be rejected if the statements in the application are found to be false or incorrect in any essential particular.

RATING OF EXAMINATION PAPERS.

METHOD OF RATING.—The following method is observed in rating examination papers by the Commission:

After an examination is held the papers are arranged by sheets or subjects and are forwarded under seal to the Commission. When they are reached in the order of rating, they are distributed by sheets to the examiners, Examiner A being given all of sheets 1, Examiner B all of sheets 2, Examiner C all of sheets 3, and so on, the sheets being distributed to as many examiners as there are subjects in the particular examination to be rated. After the papers are rated in the first instance they are redistributed, and the first rating is reviewed by other examiners. When all of the papers of an examination have been rated and reviewed, those of each competitor are then for the first time assembled or brought together, his average percentage is ascertained, his declaration envelope is opened, and the declaration sheet to which he has signed his name is attached to his examination papers. The identity of the competitor, therefore, is not disclosed *until his papers have been rated and reviewed and his average percentage determined.* As the charges for specific errors are all fixed by the rules for rating, and as each subject is rated by one examiner and reviewed by another, it will be seen that absolute impartiality, accuracy, and uniformity are secured in the work.

PREVIOUS EXAMINATION PAPERS.

AID, COAST AND GEODETIC SURVEY.

The position of deck officer will also be filled from this examination. Age limit, 18 to 25 years; application form, 1312; time allowed, two days of six hours each. The first three subjects will be given on the first day and the remaining subjects on the second day. The medical certificate on the application form must be executed by a medical officer of the Public Health and Marine-Hospital Service, except when this requirement would work a hardship upon an applicant because of his distance from such officer he may have the certificate executed by any physician, in which event, however, he may be required to pass a physical examination before an office of the Public Health and Marine-Hospital Service before appointment. Subjects of examination and relative weights of subjects on a scale of 100: Mathematics: Including geometry (plane and solid), algebra, trigonometry, and the elements of calculus, 15; Practical computations: Involving the use of logarithmic tables, 15; Astronomy: Elementary questions in spherical and general astronomy, with special reference to determination of latitude, longitude, and azimuth, and use of field instruments, 10; Physics: Elementary questions in optics, magnetism, etc., 10; Surveying: Elementary questions in plane and geodetic surveying, and use of field instruments, 10; Modern languages: Competitors may select one of the following: French, German, Spanish, Italian. Extracts of about 100 words are given for translation into English, 10; Drawing and Descriptive Geometry: A short test in topographic drawing and lettering is given with elementary questions on the principles of projection, 10; Training and experience rated on application form, 20.

The supply of eligibles for this position has not been equal to the demand.

AID, COAST AND GEODETIC SURVEY.

Mathematics.

[Logarithmic tables will be furnished.]

1. What angle does $\frac{1}{16}$ of an inch subtend at a distance of 1 000 ft.?

2. State the sum of the interior angles of a closed plane figure bounded by straight lines. Give proof.

3. What is the differential of the sine of an arc? Show geometrically its signification, and, by a practical example, the use of the result.

4. Compute all parts of a triangle having given angle A 33° 0′ 10″, angle B 45° 0′ 20″, and side AB 1 000 meters.

5. Describe the difference between the orthographic, stereographic, and different kinds of conic projections, and the advantages of each where they are employed. Explain generally the methods of descriptive geometry, and illustrate by an example.

Astronomy.

1. State the different methods of determining latitude, longitude, and azimuth, and compare their relative accuracy.

2. Give the adjustments of the transit instrument, and explain the method of making each.

3. Derive the azimuth factor, and show how it is applied in the reduction of meridian observations.

4. State approximately at what o'clock Alpha Lyræ (right ascension 18h. 33m.) comes to the upper meridian on April 26, and give the reasoning.

5. Can the southern cross, declination 62° south, be seen from the United States? Give the reasons for your answer.

Physics.

1. Name three processes by which heat is diffused.

2. What is the pressure in grams of the atmosphere on a square meter of the earth's surface at sea level, assuming the density of mercury to be 13.6? Give work in full.

3. What is meant by the C. G. S. system of units?

4. The periods of vibration of two pendulums are as 2 to 3; what is the ratio of their lengths?

5. What is an achromatic lens? What is an aplanatic lens?

6. Give a rough method of getting the magnifying power of the telescope of a surveyor's transit.

7. What is meant by the index of refraction of a substance?

8. Name the three elements of terrestrial magnetism which are usually determined by a magnetic survey.

9. Define agonic line.

10. What is meant by diurnal and what by secular variation of the magnetic needle?

Surveying.

1. Mention one method by which the size and figure of the earth can be found, and another by which its figure can be deduced.

2. Describe, briefly, two different kinds of apparatus suitable for measuring a base line.

3. What is meant by the reduction to sea level of a measured distance, and why is such a correction applied?

4. What is meant by "spherical excess," and when is it necessary to take it into account?

5. When does the sum of the azimuth and back azimuth of two intervisible stations differ from 180°?

6. A level has a scale value of 5 seconds to a millimeter; what is its approximate radius of curvature?

7. What is meant by the adjustment for "wind" in a level?

8. Represent a conical hill by six contour lines.

Geography of the United States.

1. Give the approximate geographical limits, by degrees of latitude and longitude, of the United States, and its approximate area.

2. Name the States touched by the Mississippi River.

3. Bound Illinois and Georgia.

4. Name five of the principal rivers emptying into the Atlantic.

5. Give the heights of the five highest mountain peaks in the United States, and their location, excluding Alaska.

Modern Languages.

Make a close translation of any two (and only two) of the following languages into idiomatic English:

French.—Au lieu d'enfoncer le tube dans le mercure, on peut le soulever de manière que son extrémité inférieure soit légèrement au-dessus de la surface du mercure. Comme il ne se produit plus alors une fermenture hydraulique l'élévation du niveau est presque imperceptible. Si, dans cette position du tube, on place l'anode à son intérieur, on constate naturellement un abaissement du niveau dont

la valeur est plus forte que celle de la précédente élévation. Ce résultat est dû à la différence des dimensions du tube et du vase. Dans cette dernière expérience, on peut évidemment remplacer le mercure par un métal solide; mais on remarque alors qu'il ne se produit aucune variation de niveau.

German.—Entfernt man sich in der Äquatorebene mehr und mehr und mehr von der Erde, so nimmt die Anziehung ab, die Zentrifugalkraft dagegen zu, bis endlich an einer Stelle Gleichheit eintritt. Darüber hinaus überwiegt die Zentrifugalkraft. Man kann nun diejenige Niveaufläche, in deren Äquator jene Gleichheit statt hat, als äusserste Niveaufläche bezeichnen, insofern sie unter gewissen Voraussetzungen die Grenze der Atmosphäre sein muss. Wir betrachten hier übrigens diese Fläche nur zu dem Zwecke, um an einem Biespiel zu erkennen, wie sich die Niveauflächen bei grösserem Abstande von der physischen Erdoberfläche verändern.

Spanish.—Si caen los cuerpos abandonados á sí mismos, es en virtud de una fuerza atractiva que los dirige hácia el centro de la tierra, y no por su propia espontaneidad; si disminuye gradualmente la velocidad de una bola en una mesa de billar, es por efecto de la resistancia del aire que desaloja, y por el roce sobre el tapete. Por consiguiente, de esto no debe deducirse que la bola tenga más bien tendencia al reposo que al movimiento, según decían algunos filósofos antiguos, que comparaban la materia con una persona perezosa. No habiendo resistencia, sigue sin alteracion el movimiento, como nos lo demuestran los astros en su revolucion al rededor del sol.

Italian.—I fenomeni di attrazione e di repulsione notati, possono venire indicati schematicamente come ora dirò. La fig. 2 rappresenta il caso in cui il filo A, visto in sezione, è unito metallicamente dal di fuori del tubo di scarica col catodo C. Sulla parete fluorescente si ha allora una zona M in ombra, la quale è molto più larga dell' altra mn che si avrebbe se A fosse neutro. I raggi catodici, che in questo caso sarebbero sensibilmente rettilinei, sono invece indicati in figura con delle linee di sensibilissima curvatura.

ASSISTANT EXAMINER, PATENT OFFICE, DEPARTMENTAL SERVICE.

Age limit, 20 years or over; application forms, 304 and 375; time allowed, two days of seven hours each. The first three subjects will be given on the first day, the remaining subjects on the second day. Entrance salary, $1 200. A credit not to exceed 15 per cent., and in no case to raise the competitor's grade above 100 per cent., will be given to competitors who have had actual experience in work similar to that required of assistant examiners in the Patent Office.

Subjects.	Weights.
1. Physics	20
2. Chemistry, inorganic and organic	20
3. Mathematics	10
4. Technics	20
5. Mechanical drawings	20
6. French or German (translations into English).	10
Total	100

The following questions and tests, which have been used, indicate the general character of the examination:

Physics.

1. A body whose mass is 10 grams, supported by a smooth plane inclined to the horizon at an angle of 30°, is connected by a cord passing over the head of the inclined plane to a body hanging vertically, whose mass is 20 grams. Determine the actual acceleration, and the tension of the string in dynes. ($g = 980$ cm. per sec. per sec. Give work in full.)

2. (*a*) Explain emission and absorption spectra. (*b*) What is the cause of the dark lines (Fraunhofer's lines) of the solar spectrum?

3. Give the laws governing the transverse vibration of strings.

4. (*a*) State the effect of fusion on the volume of solids, and give examples. (*b*) What is the effect of pressure on the fusing point?

5. Describe and explain Wheatstone's bridge, giving diagram.

Chemistry, Inorganic and Organic.

1. State and illustrate the law of periodicity in the properties of elements.

2. How may the molecular weight of a chemical compound that is volatile without decomposition be determined? Explain fully the fundamental principles involved.

3. Describe the preparation and properties of arsenic. Give a test for arsenic.

4. Give the formula of alcohol, aldehyde, and acetic acid. What is the relation between these substances?

5. Write the formula of olefiant gas. Of what is olefiant gas a principal constituent?

Mathematics.

1. Factor $9 - x^2 - 4y^2 + 12xy$ and $64x^2 - 12xy - 45y^2$.

2. Given $\left\{\begin{array}{ll} (x+y)^2 - z^2 = & 117 \\ x^2 - (y+z)^2 = & 13 \\ x + y - z = & 9 \end{array}\right\}$, find the values of x and y.

3. Find the equation whose roots are, 0, 3, $-1 \pm \sqrt{5}$, and a.

4. Prove that the figure formed by connecting the middle points of a trapezium, taken in order, is a parallelogram, and that its area is one-half the area of trapezium.

5. Determine the number of regular polyhedrons possible.

Technics.

Answer at least five of the following questions:

1. Describe the manufacture of kerosene from crude oil.

2. Describe the manufacture of matches.

3. Describe a time lock.

4. (*a*) What are meant by "eccentricity" and "angle of advance" as applied to valve gearing? (*b*) Describe an automatic steam governor which acts by varying these quantities.

5. (*a*) Describe, and illustrate by diagrams, the windings in a series, a shunt, and a compound-wound dynamo. (*b*) State why the last form of winding is better adapted to yield a constant potential under varying loads than the first two forms.

6. Describe the manufacture of water gas. How are the by-products separated?

7. Describe the manufacture and galvanizing of iron wire.

8. Describe the safety devices commonly employed on passenger elevators.

9. Describe the manufacture of bicycle tubing.

10. Describe the construction of a polyphase motor, and explain its mode of operation.

Mechanical Drawings.

For this subject the competitor will be given photolithographic copies of drawings of some kind, or portions of machinery, and will be required to describe the construction and operation of the machine represented, naming the different views shown, and the mechanical powers that appear. (The competitor will be instructed as to the name or use of the machine.)

French or German.

The examination is identical in scope for each language, and provides one general and two technical exercises in each language, each of the exercises containing about 125 words. The competitor must select and make translations of any two of the exercises in the language chosen without the aid of a dictionary.

ASSISTANT, NAUTICAL ALMANAC OFFICE, NAVY DEPARTMENT.

Age limit, 20 years or over; application forms 304 and 375; time allowed, two days of seven hours each. As to applying for this examination see page 4.

	Subjects.	Weights.
1.	Pure mathematics	50
2.	Practical computations	40
3.	Spherical astronomy	10
	Total	100

The following questions, which have been used, indicate the general character of the subjects:

Mathematics.

1. Solve the following:

(a) $x^2 - 5\sqrt{2x^2 - 3x - 4} - x = \dfrac{x - 25}{2}$;

(b) $\sqrt{x - \dfrac{1}{x}} - \sqrt{1 - \dfrac{1}{x}} = \dfrac{x - 1}{\sqrt{x}}$.

2. Find the sum of (a) $\frac{1}{2} - \frac{1}{4} + \frac{1}{8} - \frac{1}{16} + \ldots$ to infinity; (b) If the middle term of $(1 + x)^{2n}$ is the same as the $(n + 1)$th term of $\dfrac{1}{\sqrt{1 - ax}}$, determine a.

3. (a) Prove the binomial theorem for positive integral exponents; (b) Expand $\dfrac{1}{\sqrt[7]{(a^2 - bx)^2}}$ to 5 terms.

4. Prove that a truncated triangular prism is equivalent to the sum of three pyramids whose common base is that of the prism and whose vertices are the 3 vertices of the inclined section.

5. Deduce the formulæ for the sine and cosine of half of any angle of a plane triangle in terms of the sides.

6. Find the equations of the tangent and normal to the ellipse $\dfrac{x^2}{25} + \dfrac{y^2}{16} = 1$ at point whose abscissa is 4 and ordinate positive. Find also the length of subnormal.

7. (*a*) Given $y = (\log \sin x)^{\cos e}$, find dy; (*b*) Show the geometrical signification of the first differential coefficient of the equation to a curve.

8. Expand $\tan^{-1}x$ in ascending powers of x and determine the value of π to 5 places of decimals.

9. (*a*) State Napier's Analysis and Gauss's Equations; (*b*) Find the intercept of $y + 4x = 2$ between $5x - y = 7$ and $y = 7x - 5$.

10. State De Moivre's Theorem and show how to determine thereby the roots of $x^4 + 4 = 0$.

(Generally 10 questions.)

Spherical Astronomy.

1. Define the following: Nadir, celestial sphere, azimuth, collimation, sidereal time, aberration, ecliptic.

2. Classify eclipses and state briefly the cause of each.

3. Explain the equation of time, and represent it by a curve.

4. Give the reasons why observers on the earth have been able to see more than one-half of the moon's surface.

5. Given $3x + 2y + 1$, $2x + 3y = -1$, and $x - 2y = -2$; find the most probable value of x and y.

(Generally 5 questions.)

Logarithmic and Astronomical Calculations.

1. In a plane triangle $a = 6238.7$, $b = 2347.5$, and $C = 110° 32'$, determine A, B, and c.

2. In a spherical triangle $a = 40° 5'.4$, $b = 118° 22'.1$, $A = 29° 42'.6$; determine c, B, and C.

3. Given $x = \alpha \sin (\beta + C\gamma)$, compute 6 values of x for $C = 1, 2, \ldots 6$, when $\alpha = -0.27163$, $\beta = 143° 47'.7$, $\gamma = 117° 53'.3$; add the 6 values and check by formula, sum $= \dfrac{\alpha \sin (\beta + \frac{7}{2}\gamma) \sin 3\gamma}{\sin \frac{1}{2}\gamma.}$

4. Given $\rho \cos \delta . \cos \alpha = X + x$; $\rho \cos \delta \sin \alpha = Y + y$, and $\rho \sin \delta = Z + z$, where $\log x = 0.24332$, $\log y = 9.88888^n$, $\log z = 8.29369^n$, $X = 0.63451$, $Y = -0.23688$, and $Z = -0.00246$; determide ρ, δ, and α (ρ being positive).

5. Given $N = \dfrac{10^{1.0792}}{D^{0.708}.}$ Compute values of N for $D - 0.04$ and 0.15

(Generally 10 questions.)

SUPERINTENDENT OF CONSTRUCTION, SUPERVISING ARCHITECT'S OFFICE, TREASURY DEPARTMENT.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. The first subject will be given on the first day and the remaining subjects on the second day. An applicant must have had at least five years of practical experience in building construction, either as a superintendent proper, contractor, architect, or engineer, and must establish this experience to the satisfaction of the Commission prior to being admitted to the examination. Subjects of examination and relative weights of subjects on a scale of 100: materials and building construction, involving extensive knowledge of all materials employed in first-class buildings and of details of construction, 40; mathematics, comprising arithmetic, accounts, and elements of plane geometry and mensuration, 10; building supervision, tests in the form of business communications which require adaptability, a knowledge of the qualifications necessary for this position and knowledge of the work gained by experience, 15; specifications, involving knowledge of the details of complete specifications for the various classes of work required in first-class buildings, 10; training and experience (see sec. 30 for time of filing application), 25. The duties of the position require the appointee's continuous residence in the city where the building under his superintendence is being constructed; but, as the necessities of the service require that superintendents of construction of public buildings shall serve in any part of the United States, they may be detailed from building to building as required.

The following questions and tests which have been used indicate the general character of the examination:

Materials and Construction.

1. What are the requisites of first-class building brick, of best quality lime, and of best quality building sand?

2. What are the characteristics of good cement; what tests are necessary to determine its quality, and in what respects do Rosendale and Portland differ?

3. (*a*) What is "dry rot" and how is it prevented in buildings? (*b*) What are the requirements of first-class yellow-pine lumber? (*c*) In what respects do cast iron, malleable iron, and steel differ?

4. (*a*) What is quarry water, what is its effect on stone, and how is it gotten rid of? (*b*) Compute the number of cubic feet of well-rammed concrete to be obtained from the following materials: Three bbls. (packed) Portland cement, 11 bbls. sand, 9 bbls. gravel, and 15 bbls. ordinary broken stone. (Show work in full.)

5. In foundations, what various means are adopted to increase the bearing capacity of a yielding soil?

6. (*a*) What precautions must be taken to insure good joints and bond in (1) brick masonry, (2) ashlar facing with brick backing? (*b*) Give a pen-and-ink sketch of section and plan of a fireplace, with hearth and trimmer arch, opening 2 ft. 6 in. high, 3 ft. wide, and 16 ft. deep.

7. What is "slow-burning construction"? Give a neat pen-and-ink sketch of the post-and-girder connections and of the floor construction of a building of this type.

8. Give pen-and-ink sketch of sections through head, sill, and jamb of a sliding-sash window frame; name the different parts, and specify the material for each part.

9. Give neat pen-and-ink sketch of sections through a door jamb, and through the stile of a veneered door; name the different parts in each case, the materials for each part, and describe or show plainly by sketches the method of construction.

10. Make a neat pen-and-ink sketch showing longitudinal section through string of an iron staircase with marble treads; also show a section of gallery casing in a fireproof building, the floor to be of marble.

ARITHMETIC AND MATHEMATICS.

1. Extract the square root of 492,868.586116.

2. A contractor agrees to complete a piece of work in 30 days, and puts 17 men to work on it, the working day being 8 hours. At the end of the 13th working day 5 men quit work, and he finds that only $\frac{1}{3}$ of the work has been done. How many extra men, provided the total force works hereafter 9 hours per day, will it be necessary for him to hire at once so that he may fulfill his contract?

Divide $5\frac{2}{5}$ by $\frac{9}{32}$, multiply the quotient by 3.5468, and from the product subtract $\frac{11}{16}$ of 13.76.

4. The depth of a building lot is one foot less than double its frontage. If a strip 1 yd. wide be taken off all around, the area is diminished 210 sq. ft. What is the area of the original lot in square feet?

5. The plan given shows excavation for house. General excavation is 6 ft. 9 in. deep and deep-area windows 4 ft. 8 in. deep. The ground is level. Find total excavation in cubic yards.

6. The area of a circle is 272 sq. ft. Find its radius and circumference in feet and inches.

7. The axes of an ellipse are 4 and 6 in., respectively. Show one method of constructing it graphically.

8. A beam of uniform cross-section 25 ft. long and weighing 50 lb. per ft. is placed on a rail. It has a load of 150 lb. at 2 ft. from one end and 400 lb. at 5 ft. from the other. If there is equilibrium, find position of supporting rail from each end of beam in feet and decimals of a foot.

9. Given two circles of different radii, one of which lies either wholly or in part outside of the other, show, geometrically, how to draw a straight line tangent to both circles.

10. From the given sketch calculate the strains on the jib and the chain of this crane. State whether tension or compression.

Building Supervision.

1. (*a*) State what mental and moral qualities a successful superintendent must possess. (*b*) State what technical qualifications he should possess.

2. (*a*) How would you check the stakes defining the lot on which a building is to be erected, under your superintendence, and how would you fix them for future reference? (*b*) What points would you attend to in the excavation for foundation?

3. (*a*) The foundation having been excavated to the depth specified, how would you test its bearing capacity? (*b*) If its capacity did not come up to requirements of specification, what would you do?

4. If the nature of the soil is such that wooden piles must be used and have been specified, state fully what you would do, as a superintendent, from the time of arrival of the piles on the ground until they are driven in conformity to contract requirements.

5. State what precautions you would take in order to obtain the best quality of work and best results in foundation footings (*a*) of concrete, (*b*) of brick, and (*c*) of stone.

6. In the superintendence of cut work, either in granite, sandstone, or limestone, what precautions would you take in order to obtain the specified standard (*a*) in material, (*b*) in the cutting and molding, and (*c*) in the setting of the stone?

7. If, in your opinion, the contractor is using material not up to specification, or the quality of the work done, through inefficiency of workmen or other cause, is not first-class; and, generally, when the work in any respect is not being conducted or performed accord-

ing to your interpretation of specification and contract, state, in detail, what course or courses you would pursue.

8. State what general considerations should govern a superintendent's course of action in all matters relating to his work.

Specifications.

(*a*) Give the general heads for a specification for a small brick office building with fireproof floors and roof. (*b*) Give rough draft of specification for the brickwork, woodwork and ironwork for the same.

DRAFTSMAN, TOPOGRAPHIC.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six hours each. Subjects of examination and relative weights of subjects on a scale of 100: Drawing, a specimen of topographic drawing will be given for reproduction, in India ink, 35; Lettering, tests on short words and numbers in different styles of lettering, 35; Mathematics, comprising arithmetic, algebra to and including problems involving quadratics, plane and solid geometry, plane trigonometry, logarithms, mensuration and projections, 30.

The supply of eligibles for this position has not been equal to the demand.

NOTE.—Competitors who fail to attain an average rating of at least 70 in the subjects of drawing and lettering will not be eligible for appointment. Not more than four hours will be allowed on the second day for work on drawing and lettering. No submitted drawings will be accepted. Competitors who average 70 per cent. or over in the subjects of drawing and lettering may also have their names entered on the copyist topographic draftsman register, provided that they each file an application for copyist topographic draftsman in ample time for the examination.

DRAFTSMAN, COPYIST TOPOGRAPHIC.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and four hours, respectively. Subjects, examination and relative weights of subjects on a scale of 100; Drawing, a specimen of topographic drawing will be given for reproduction in India ink, 50; Lettering, tests of short words in different styles of lettering and numbers are given, 50. The tests in drawing and lettering are identical with those given in the topographic draftsman examination. Competitors who take both examinations will take these tests but once. No submitted drawings will be accepted.

The following questions and tests which have been used indicate the general character of the subjects of geographic projections, geography, and mathematics:

Geographic Projections.

State fully and clearly the principles of polyconic projection, and describe in detail the process of constructing, by this projection, a map of that part of the United States and Canada lying between 30° and 50° north latitude and 70° and 90° west longitude. The scale of the map is to be $\frac{1}{1\,200\,000}$.

Geography.

1. Name five States bordering on the Great Lakes and name an important river in each of the States required.

2. Name five States which border on the Missouri River, and name the capital of each State required.

3. In what State is each of the following-named located: Fremont Peak, Tulare Lake, Mount Mitchell, Schoodic Lakes, Mount Baker?

4. Name the most populous city in each of the following-mentioned States and the river or body of water on which each is situated: Connecticut, West Virginia, North Dakota, Washington, Arkansas.

5. Name two States which border on each of the following-mentioned rivers or bodies of water: Potomac River, Lake Champlain, Savannah River, Columbia River, Sabine River.

Mathematics.

1. Same as question 1 of the arithmetic of first grade, see Sec. 35.*

2. Divide $5\frac{2}{5}$ by $\frac{9}{32}$, multiply the quotient by 3.5468, and from the product subtract $\frac{11}{16}$ of 13.76.

* See Manual of Examinations, U. S. Civil Service Commission.

3. Three draftsmen, *A*, *B*, and *C*, are engaged upon a piece of work. *A* can do it alone in 7, *B* in 15, and *C* in 21 days. After the three men work together $1\frac{3}{8}$ days *B* stops work. How long will it take *A* and *C*, working together, to complete the work?

4. Extract the square root of 94,254.526081.

5. What size sheet of paper, in inches, would be required for a map covering one degree of latitude and longitude, on a scale of $\frac{1}{80000}$, to allow a margin $1\frac{1}{4}$ in. wide all around, outside the neat lines, if one minute of latitude is equal to 1,850 meters and one of longitude on the largest arc is equal to 1,356 meters?

6. Show how to draw a circle through three given points not on a straight line, and prove your construction.

7. Find the point on a given straight line, such that the sum of the distances from it to two given points not on this line may be the least possible.

8. Given $\frac{x-5}{4} - \frac{2x-y-1}{3} = \frac{2y-2}{5}$, and

$$\frac{2y+x-1}{9} = \frac{x+y}{4},$$ find x and y.

9. Given $x^2y + xy^2 = 20$, and $\frac{1}{x} + \frac{1}{y} = \frac{5}{4}$, find x and y.

10. In a triangle *A B C*, the angles *A* and *B* and the side *a* are given. Write down the formulæ for finding *C*, *b*, and *c*, and express the logarithms of these in terms of those of *A*, *B*, and *a*.

No specimen questions in the fifth, sixth, and seventh subjects can be furnished.

DRAFTSMAN, ARCHITECTURAL, SUPERVISING ARCHITECT'S OFFICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of eight hours each. The first two subjects will be given on the first day and the third subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Building materials and construction, involving extensive knowledge of all materials employed in first-class buildings, of details of construction, and of specification forms for such work, 25; free-hand drawing, ornament and projection, involving ability to make free-hand perspectives, large-scale free-hand drawings of styles of exterior and interior decoration and shadow casting, etc., 25; drawing and design, involving the drawing of plans, elevations, and details for modern first-class buildings to scale according to given specification, 30; training and experience, 20.

DRAFTSMAN, JUNIOR ARCHITECTURAL, SUPERVISING ARCHITECT'S OFFICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. The first two subjects will be given on the first day and the remaining subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Materials and building construction, elementary questions in materials and details of construction, 25; free-hand drawing and projection, elementary questions involving ability to draw perspective views, plans, and elevations of regular solids, examples of decoration, cast shadows, etc., 25; drawing, involving ability to draw neatly and correctly to scale, sketch drawings submitted, 40; training and experience, 10.

The following questions and tests which have been used will indicate the general character of the above-named examinations:

(a) Junior architectural draftsman.

ELEMENTARY MATHEMATICS.

1. This question comprises a test in adding figures crosswise and lengthwise. There are usually three columns of about twelve numbers each to be added.

2. Multiply 382.58 by $\frac{3}{7}$ of 27.342, and divide the product by $\frac{1}{2}$ of 34.78. (Work by decimals.)

3. Extract the square root of 492,868.586116.

4. Given a straight line of definite length, show how to divide it graphically into four parts proportional in length to the numbers 1, 2, 3, and 5.

5. Describe a circle through any three given points not in a straight line, and prove your construction.

Knowledge of Materials and Construction.

1. What are the characteristics of first-class building brick, best quality lime and building sand?

2. Name four different bonds employed in brickwork. Make neat pen-and-ink sketch plans and elevations of each.

3. Explain or show by sketch the best method of framing studs and joists on sills, and make, also, a neat sketch section through the sill and the stone foundation of a frame house.

4. Make a sketch section and elevation in ink, showing the construction of an ordinary panel door; name all the parts. Draw a sketch about one-sixth full size, showing section through a veneered door.

5. Show by a sketch the method of framing a floor around a chimney in an outside brick wall, and name the different parts of the framing.

Orthographic Projection and Free-Hand Drawing.

A right regular triangular prism, whose height is $2\frac{1}{2}$ in., and the edge of whose ends is $1\frac{1}{2}$ in., stands on one end as a base, with two edges of base equally inclined to the vertical plane. The center of the base is $1\frac{1}{4}$ in. from the vertical plane.

1. Draw plan and elevation, and show true form of section made by a cutting plane at right angles to the vertical plane, at 45° to the horizontal plane, and bisecting the axis of the prism.

2. Draw the development of the lower part of the prism.

3. Make free-hand drawing in pencil of sketch of ornament furnished, enlarging to twice the size there shown.

4. Make free-hand drawing in ink of the study for house, enlarging to twice the size there shown.

Architectural Drawing.

1. Name the five orders of architecture and the principal parts into which an order is divided.

2. Draw, in pencil, a Roman Doric cap, using 2 in. as a module.

3. The plan given on sheet $5a$ is to $\frac{1}{32}$-in. scale. Enlarge to $\frac{1}{16}$-in. scale and finish in pencil.

4. Make a copy of the elevation given on the same sheet, in pencil. Use the same scale as in copy. Finish one bay complete.

5. Make a tracing, in ink, of your drawing furnished in answer to 4.

NOTE.—The drawing given in connection with questions 3, 4, and 5 will be a simple plan and elevation of a small public building.

(b) Architectural draftsman.

KNOWLEDGE OF MATERIALS AND CONSTRUCTION.

1. Give, to about 1-in. scale, a sketch plan and section of a fireplace with hearth and trimmer arch, the opening to be 2 ft. 6 in. high, 3 ft. wide, and 16 in. deep.

2. Give two sketch plans of a brick pier between two windows, faced with ashlar, showing the bond of the ashlar and the anchors and cramps required to bond the work.

3. What is "slow-burning construction"? Give a pen-and-ink sketch of the post and girder connections and of the floor construction in a building of this type.

4. Of what materials are (1) concrete, (2) lime mortar, (3) cement mortar, (4) first coat of plaster composed; in what way is each used, and in what proportions are the materials mixed in each case?

5. What are the characteristics of good common brick and good building sand, and what tests would you employ to ascertain their quality? In what respects do Rosendale and Portland cements differ?

6. Give sections through the head, sill, and jamb of a sliding-sash window frame, name the different parts, and specify the material of which each part should be made.

7. What are the characteristics of first-class yellow-pine lumber? Define wet-rot and dry-rot, and state how each is prevented.

8. How would you specify a joint to be made between (*a*) cast-iron pipes and (*b*) between a cast-iron pipe and a lead one? What minimum fall would you allow in a sewer from house to street?

9. Show, by a neat pen-and-ink sketch, the proper method of arranging a ventilated running trap outside the wall of a building and on the line of pipe connecting the sewer.

10. Make a neat pen-and-ink sketch showing longitudinal section through string of an iron staircase with marble treads; also show a

section of gallery casing in a fireproof building, the floor to be of marble.

The drawings required to be made under instructions given above represent elevation and first-floor plan of a federal building. Stone facing. Fireproof construction.

1. Give the headings of the principal subjects to be covered in a specification for such a building.

2. Give a short outline draft of a specification for the cut-stone work.

3. A short outline draft for the brickwork.

4. A short outline draft for the carpenter work.

5. A short outline draft for the painting and glazing.

Drawing and Design.

1. Name and describe in outline the Greek and Roman orders, mentioning the principal points in which they differ.

2. Draw, in pencil, with a module of ½ in., the Corinthian order, and give the proper technical name for each of its parts and members.

3. Lay out, in pencil, to ⅛-in. scale, the sketch plan shown on sheet *4a*, and figure your drawing fully.

4. Lay out the elevation, in pencil, to the same scale, finish one-half of your drawing, and figure the openings.

5. Make a tracing in ink, on linen, of your drawings in answer to questions 3 and 4, and letter the tracing neatly.

For questions 3, 4, and 5 a rough sketch plan and elevation of a public building was given.

Free-hand Drawing and Orthographic Projection.

Give finished pencil sketches of two of the following-named styles of ornament, and indicate your selection:

1. Greek or Roman. (Select one.)

2. Gothic or Renaissance. (Select one.)

3. A right, regular octagonal prism, whose height is 3 in. and the edge of whose ends is 1 in., stands on an edge of one end on the horizontal plane, with its axis parallel to the vertical plane, at 60° to the horizontal plane and 1½ in. from the latter. The edge on a

horizontal plane is inclined at 60° to the vertical plane. Draw plan and elevation.

4. Show true form of section made by a horizontal cutting plane which bisects the axis, and develop the lower part of the prism.

5. An octagonal column, 3 in. high, and the diagonals of whose base are $2\frac{1}{2}$ in., stands vertical and has a plinth 4 in. square and 1 in. thick lying flat on top. One face of the plinth and one of the column show full in elevation. Show exact form of shadow cast by plinth on column by a direct light falling at 45°, as is usual in drawings.

(c) Structural-steel draftsman.

HIGHER MATHEMATICS AND MECHANICS.

6. Assuming the formula for determining the solidity of a cone as proved, show that the volumes of two similar cones of revolution are to each other as the cubes of their heights.

7. Given two adjacent sides, *a* and *b*, of a triangle, and also the included angle *C*, show how to solve the triangle.

8. Find the points where the straight line $y = \frac{3}{4}x + a$ cuts the parabola $y^2 = 4ax$, and the length of the part intercepted.

9. Given $x^3 + y^3 - 3axy = c$; find $\frac{dy}{dx}$.

10. Integrate $\frac{3x - 5}{x^2 - 6x + 8}dx$.

11. A 20-in. I-beam, 70 lb. per ft., has an 8 by $\frac{1}{2}$-in. plate riveted on the bottom flange. Find the position of the center of gravity, the moment of inertia, and the radius of gyration of the combined section. (Moment of inertia for 20-in. I-beam 70 lb. per ft. = 1 220.)

12. A steel plate girder 30 ft. long and 3 ft. deep carries a center load of 30 000 lb. and a distributed load of 2 000 lb. per ft. If the maximum strain on extreme fibers is 15 000 lb. what is the moment of inertia of the section?

13. A beam 25 ft. long has a load of 10 000 lb. at 5 ft. from one end and a distributed load of 1 000 lb. per foot. What is the maximum bending moment, and where does it occur?

14. State the theorem of (*a*) the parallelogram of forces; (*b*) the parallelopiped of forces, and (*c*) the resultant of any number of parallel forces.

15. Three forces, *A*, *B*, and *C*, are in equilibrium. Having given the magnitude and direction of *A*, the magnitude of *B*, and the direction of *C*, determine the magnitude of *C* and the direction of *B*. When is the solution impossible?

Knowledge of Materials, Drawing and Design.

(Use of slide-rule is permitted in computations.)

1. Figure the strains on the members of the truss shown below. Assume wind pressure as 40 lb. per sq. ft. horizontal; snow, roof, and covering as 40 lb. per horizontal sq. ft. Truss is fixed at *A* and rests on steel built column 20 ft. high; free at *B*, resting on rollers on brick wall. Distance between trusses is 10 ft. To prevent bending of column a knee brace is to be provided. Distance from foot of column to knee brace is 12 ft. Show all your calculations. (A Fink roof truss, 100 ft. span and 25 ft. rise, was given.)

2. Show, in pencil, details at *A* and *B*, and of foundation of column, so that maximum pressure on subsoil may not exceed 1 000 lb. per sq. ft. Find, also, strain in knee brace and bending moment on column.

3. (*a*) Describe briefly the process to which ore is subjected before it is suitable for structural cast-iron work. (*b*) Name and describe, in detail, one method of making steel.

A. A floor space, 25 by 40 ft. clear, is to be covered with a steel beam and girder floor without columns. The total floor load, including weight of floor, is 400 lb. per sq. ft. Allowing maximum strain on fibers of 15 000 lb. per sq. in., show by a neat pen-and-ink figured sketch the most economical and suitable arrangement. Add written notes when necessary. The moment of inertia of 10-in. I-beam 25 lb. per ft. is equal to 122.5; 10-in. I-beam 33 lb. per ft. is equal to 161.3; 12-in. I-beam 32 lb. per ft. is equal to 222.3; 12-in. I-beam 40 lb. per ft. is equal to 281.3; 15-in. I-beam 41 lb. per ft. is equal to 424.1; 15-in. I-beam 50 lb. per ft. is equal to 529.7; 15-in. I-beam 60 lb. per ft. is equal to 644; 15-in. I-beam 80 lb. per ft. is equal to 785.

5. A plate girder 27 ft. long and 3 ft. deep carries a load of 3 000 lb. per ft. and a concentrated load of 50 000 lb. at 6 ft. from each end. Proportion the girder to sustain this total load, allowing maximum flange strain of 15 000 lb. per sq. in., and shear in web and rivets of 8 000 lb. Show all your calculations.

6. Make detail drawings, in pencil, of the girder to $\frac{3}{4}$-in. scale. Figure all dimensions and rivet spacing.

7. A column carries, at first floor level, four beams. The beams are arranged and transmit to the column the loads as shown on the

sketch below. Length of column is 13 ft. from base to top of beam at first floor and 25 ft. from top of beam at first floor to top of beam at second floor. The column rests on a concrete base and is to be built of plates and angles. Design the column and all connections. Assume strain on column as 10 000 lb. per sq. in., shearing value $\frac{7}{8}$-in. rivets as 6 000 lb., and bearing value of $\frac{7}{8}$-in. rivets as 15 000 lb. per lin. in. of bearing. Allow pressure on concrete base of 8 tons per sq. ft. Show all your calculations.

8. Make a drawing, in pencil, of the column, showing all connections and base.

NOTE.—For question 7 the column carries, at first-floor level, four beams at right angles, in pairs, and unequally loaded; at second-floor level three beams, unequally loaded and at 120° to each other, are carried.

(d) **Heating and ventilating draftsman.**—First subject same as in junior architectural draftsman.

PRACTICAL KNOWLEDGE OF HEATING AND VENTILATION.

1. Name the various means employed for warming buildings and briefly describe the principal systems.

2. Describe the construction of the usual style of direct radiators used for direct hot-water heating.

3. State the difference between direct steam radiators and those used for direct hot-water heating.

4. Where should automatic air-valve be located on a direct steam radiator, and also on an indirect steam radiator?

5. (*a*) How should flow and return pipes of a low pressure steam heating apparatus be graded? (*b*) How should similar pipes of a low temperature hot-water heating apparatus be graded? (*c*) How is air expelled from a hot-water heating system?

6. Explain the use of eccentric fittings in the pipe system of a steam-heating apparatus.

7. What is the relative position of outlets of a 6 by 4 by 2-in. eccentric "T" placed in the main flow pipe of (*a*) a low-pressure steam-heating apparatus, and (*b*) a low-temperature hot-water-heating apparatus?

8. State how globe-valves should be placed on horizontal steam-flow pipes.

9. Explain the use and operation of automatic air-valves on steam radiators.

10. To warm and ventilate a building it is necessary to introduce 570 000 cu. ft. of fresh air per hour, which amount of air is to be heated from plus 20° to 110° Fahr. by indirect radiation. The indirect radiation to be used will emit 470 h. u. per sq. ft. per hour. How many square feet of indirect radiation will be required.

Drawing and Design.

1. (*a*) Illustrate by free-hand sketch how drip pipe from a vertical steam-flow riser is run and connected to the corresponding return riser, both flow and return risers being valved. (*b*) Make a free-hand section of a 2-in. globe valve. Sketch to be made approximately full size and clearly show construction of valve.

2. Draw three-fourths-inch scale section of an indirect radiator of a low-pressure steam-heating apparatus, located in a brick chamber in the basement of a building. The indirect radiator to be located and shown in outline only; but connections to same, including valves, cold-air supply duct with damper, hot-air exit flue, construction of ceiling of chamber, manholes, etc., must all be fully illustrated. Drawing to be clear and distinct and to be made in pencil only.

3. Make finished ink drawing, side and end elevations and section through trench and part section of wrought-iron blow-off tank and pipe connections to same, all as illustrated by sketch furnished. End elevation to be taken from line *a b*, scale to be ¾ in. to 1 ft.

(e) **Electrical engineer and draftsman.**—First subject same as in junior architectural draftsman. Specimen questions in second and third subjects can not be furnished at this time.

CIVIL ENGINEER, DEPARTMENTAL SERVICE.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and three hours, respectively. The first two subjects will be given on the first day and the third subject on the second day. Subjects of examination and relative weights of subjects on a scale of 100: Pure and applied mathematics, elementary problems in mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics to and including calculus, 20; use and construction of instruments, and surveying, comprising transit, including stadia work, level, plane table, rod, chain, tape, current meters, etc., surveying, leveling, and other field work required in civil engineering and not covered in subject 1, 30; design and construction, involving elementary knowledge of designing and constructing highways, railroads, dams, retaining walls, foundation work, trusses, etc., 25; training and experience (see Sec. 30 for time of filing application), 25.

NOTE.—No applicant who has not had at least five years' good experience in civil engineering work will be admitted to the examination. Graduation in civil engineering from any reputable technical school will be considered equivalent to three and one-half years of this period. Students of civil engineering about to graduate or just graduated, and others who have filled minor positions such as chainmen, rodmen, levelmen, etc., and who have not received a suitable technical training, are advised to apply for subordinate positions under the Engineer Department in their locality.

CIVIL ENGINEER, PHILIPPINE SERVICE.

Age limit, 18 to 40 years; application forms, 2, including medical certificate, and 375. For description of examination see Sec. 65. For further requirements see Sec. 35.

Appointments will be made at salaries ranging from $1 400 to $1 800, depending upon the rating received in the examination and the amount of practical experience gained subsequent to graduation. Under the provisions of Section 21 of the Philippine civil service act, the higher positions are filled by promotion, without examination, of persons in the classified service who are, in the judgment of the appointing power, available and possess the qualifications required. There are at present about eighty civil engineer positions in the Philippine service, ranging from $1 200 to $5 400 per annum. Of this number nine receive $3 000 per annum or more.

CIVIL ENGINEER AND DRAFTSMAN.

Age limit, 20 years or over; application form, 1312; time allowed, two days of six and seven hours, respectively. The test in civil engineering will occupy the two days and will be identical with the civil engineer examination, so that those who intend to qualify as draftsmen will take this test but once. The test in drawing will be given on completion of the civil engineer examination. No submitted drawings will be accepted.

All eligibles in the civil engineering subjects who receive a rating of not less than 70 per cent. on the drawing test will be eligible as civil engineers and draftsmen. Those who fail to receive a grade of 70 per cent. on the drawing will be eligible as civil engineers only. In determining the average percentage, the subjects of the civil engineer examination will be given a weight of 60 and the subject of drawing 40.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven hours each. First day, subject 1, and subject 2 begun; second day, subject 2 finished and subject 3. Subjects of

examination and relative weights of subjects on a scale of 100: Mathematics, elementary problems in mensuration, solution of plane triangles, and theoretical and applied mechanics, involving a fair knowledge of pure mathematics up to and including calculus, 15; theory and practice of surveying and use and care of instruments, comprising transit, including stadia work, level, plane table, rods, chain, tape, etc., surveying, leveling, and other field work required in civil engineering, 30; building construction, specifications, etc., involving good knowledge of all materials employed in first-class buildings and of details of construction and of specifications, 30; training and experience.

IRRIGATION ENGINEER, GEOLOGICAL SURVEY.

Age limit, 20 years or over; application form, 1312; time allowed, two days of seven consecutive hours each. The medical certificate in application form 1312 will be required, and those who are not physically sound and able to perform field duty under trying conditions will not be admitted to the examination. The first three subjects are given on the first day, the remaining subjects on the second day.

Subjects of examination and relative weights of subjects on a scale of 100: Mathematics, pure and applied; algebra, including problems involving quadratics; plane and solid geometry; plane trigonometry, and elementary problems in applied mechanics, 10; topographic and construction sketching and lettering, competitor must show ability to make intelligible drawings of engineering and topographic features, 10; general surveying, topographic, hydrographic, and United States, theory and practice as covered in Manual of General Land Office and first-class surveying text-books, 15; engineering and hydrographic construction, questions to illustrate the general practice used on works both on land and in water, including strength of materials and specifications for the same, 20; discussion of engineering and hydrographic data, the preparation of brief papers on various practical hydrographic problems connected with irrigation, power, water supply, sanitary engineering, etc., 15; training and experience.

From the eligible list obtained from this examination vacancies occurring in the various grades of the Engineering and Hydrographic Corps will be filled, including positions of assistant engineer and of hydrographer. The salaries range from $1 000 to $2 000 and upward. Subsistence and traveling expenses are paid when on field duty. The salaries will depend upon the experience of the competitors.

ENGINEER INSPECTOR.

TECHNICAL.

1. State all the ways in which you would examine the notes of a closed survey to test its accuracy, both as to angular and linear measurements.

2. What is the fundamental requirement in all foundations to insure equality of settlement in all parts?

3. (*a*) What points have to be considered in determining the bearing power of piles in any given case? (*b*) State the circumstances, if any, where other than vertical force must be considered.

4. Aside from construction and the wearing surface of streets and roads, what important considerations govern the design and execution of such works to insure permanency and freedom from unevenness in wear?

5. Suppose you were ordered to make hydrographic survey for several piers on the North River side of the city; state clearly how you would lay out the work, what you would do and how you would do it. Illustrate by sketches, if you so desire.

6. (*a*) Describe the method of making a survey of a reservoir site. (*b*) State clearly the method of computing the cubical contents of such reservoir to the flow line.

7. Bearing and length of tangents given, (*a*) show how you would lay out a simple railroad curve by use of transit instrument. (*b*) Show at least one way of doing the same by use of chain or tape only.

8. A culvert to care for certain surface drainage is to be built under a road; show how you would determine the necessary site.

9. Describe the proper construction of a weir for measuring the flow of water, and the precautions to be observed in its use.

10. Suppose the upper surface of a dam to be vertical; (*a*) state at what depth the center of pressure of the water could be located. (*b*) State what the pressure per foot of length of the dam would be, taking the depth as (*a*).

11. What other ways are there for measuring the flow of water than by the use of weirs?

12. (*a*) Describe the action of the internal forces in a beam under transverse load. (*b*) Give the relation between a central load (P) and the unit strain (S) on a beam of length (l), depth (b) and width (w).

13. Describe what is meant by the term "shear" in computing the strength of bridges and how it is determined.

14. In riveted work the bearing value and the shearing value have both to be considered. (*a*) Describe the cases in which each may be the governing element in computing the strength of the work. (*b*) About what values would you take for each?

15. Why is it desirable that the center of pressure in masonry (as in the keystone of an arch) or in a foundation (as that of a retaining wall) should not lie outside of the middle third of the joint? Is such condition necessarily fatal to the work?

Mathematics.

(Note: Show every figure.)

1. Compute the number of square feet of pavement in a street 50 ft. between curbs and on a curve of 75° with a radius of center line of 500 ft.

2. A rectangular field is 60 ft. long and 40 ft. wide, and is surrounded by a road of uniform width, having an area equal to that of the field; what is the width of the road?

3. The population of the upper and lower parts of a town were equal, and after the former had fallen 20 per cent. and the latter risen 15 per cent., the total number of inhabitants was 39,390. What was the population of each part at first?

4. Extract the square root of 100.0200013.

5. Subtract the sum $a - x - a - x - (2x - 4)$ and $a - x - a\,x - (a - 2x)$ from $2a - x$.

Reports.

Write a report on a new street of considerable length in one of the annexed districts. Begin with the original survey, followed by the location, adoption of grades (with reasons for all conclusions), a schedule of quantity to be used in letting of the work, and inspection of grading, and of paving with granite block pavement.

CIVIL ENGINEER AND SUPERINTENDENT OF CONSTRUCTION.

1. A road is to be built 25 ft. wide. State how to calculate cut and fill, and how to establish grade line embankment 1½ to 1 ft.

2. Two guy ropes 15 ft. in plan. Figure out all stresses on various parts, jib, two guy ropes and chain. Name nature of stresses. Graphic method preferred.

3. If you have the use of a transit for field work and same is in perfect condition, state in detail how you would proceed to keep it in its parts and as a whole in that condition.

4. (*a*) State clearly the principle on which stadia measurements are based. (*b*) Explain and illustrate by large sketch the reading of the vernier. (*c*) Describe in detail the construction of a plane table.

5. If a line is to be run and chained across a stream with high shore and chaining is impossible, state in detail how to obtain the distance, the line crossing the stream at an agle of 65 degrees.

6. If a line of levels contains an error, state how to correct it, if corrections can be made at all.

7. State three different methods of surveying and discuss their respective methods.

8. When is it necessary to use piles for foundations? What is sometimes used instead of piles? Do pile foundations give entirely satisfactory results? How is the bearing capacity of piles computed?

9. Show by neat pen-and-ink sketch two different sections through ceiling and roof of a first-class fire-proof building.

10. Show three courses of bond, English, Flemish and American, on corner of 2½ ft. brick wall.

11. Show by sketch how a sewer-pipe connecting house with main sewer is trapped and ventilated.

12. Show base and elevation of a Z-bar column.

13. Write specification for concrete work.

14. Show by neat pen-and-ink sketch how pressed brick are bonded into rough brickwork.

15. Show by sketch a section about full size of a bar of copper skylight.

16. Show connections of three different sizes of I-beams.

17. Test in drawing and lettering.

Knowledge of Materials and Construction.

1. Of what materials are concrete, lime mortar, and first coat of plaster composed, in what way is each used, and in what proportions are they mixed?

2. What are the characteristics of good common brick, and good building sand, and what tests would you employ to ascertain their quality?

3. (*a*) In what respects do Rosendale and Portland cements differ? (*b*) What are the characteristics of first-class pine lumber?

4. Define and illustrate the following terms: (*a*) Needles; (*b*) Grout; (*c*) Fire Stops; (*d*) Templets; (*e*) Beds and builds; (*f*) Chases; (*g*) Bush hammered; (*h*) Staggered; (*i*) Crandalled; (*j*) Briquettes.

5. Give a plan and elevation of the floor framing around a chimney in an outside brick wall, and name the different parts.

6. Describe two different ways of securing ashlar facing to backing.

7. Give a section through a door jamb and through the style of veneered door. Name the different parts and materials for each.

8. (*a*) How would you specify joints to be made (1) between cast-iron pipes and (2) between a lead pipe and an iron one? (*b*) What is the least fall per foot that you would specify for a sewer from house to house.

9. Give sections through the head, sill and jamb of a sliding sash window-frame, in a brick wall, name the different parts, and specify the materials for each part.

10. Name four different bonds employed in brickwork. Make neat pen-and-ink sketch, plans and elevations of each.

Specifications.

For this subject the competitor will be given four drawings of the elevations and plans of a federal building and will be required to write a preliminary block specification, sufficiently detailed to enable a contractor to make a preliminary estimate.

Computing Quantities.

1. From the elevations and plans of the federal building given under the subject "specifications," take out the quantities of the brickwork.

2. From the same drawings, take out the quantities of the stonework.

3. Calculate the quantity of lumber (board measure) in the frame of the sides, floor, and roof of a framed structure of the following dimensions: 28 by 20 ft.; 12 ft. from top of sill plate to under side of cap plate; roof, ⅓ pitch and placed longitudinally of building; sill, 4 by 8 in.; floor joists, 3 by 12 in., spaced 16 in. on centers; vertical studs, 3 by 4 in., spaced 16 in. on centers; corner studs, 4 by 4 in.; cap plates, 2 by 4 in.; rafters, 2 by 6 in., 16 in. on centers; ridge piece, 2 by 8 in.

4. (*a*) Calculate the weight, in pounds, of a C. I. column of the following dimensions: Length of shaft, 16 ft.; outside diameter, 15 in.; thickness of metal in shaft, 1¼ in. At each end is a circular flange 1 in. thick and projecting 3 in. beyond outside diameter of column. There are four stiffening ribs at each flange 1 in. thick and 3 in. deep. (*b*) Calculate the weight, in pounds, of a steel girder 30 ft. long; total depth at center, 3 ft. 4½ in.; flanges, each 15 by 1 in., with additional plate, 15 ft. by 15 in. by 1 in.; web, ½ in.; angle irons, 4½ by 4½ by ⅝ in.; rivets, ¾ in., and 3-in. pitch throughout. Omit joint covers in estimation.

For questions 1 and 2, two plans and elevations of a small post-office building will be given.

EXAMINATION FOR ASSISTANT CIVIL ENGINEERS, PANAMA CANAL, JAN. 30 AND 31, 1905.

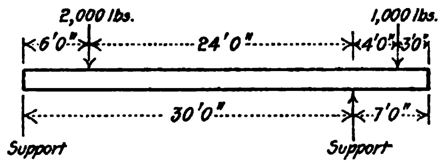
Relative weights:

Mathematics	20
Instruments	10
Surveying	10
Design and construction	20
Training and experience	40
	100

Two days of 7 consecutive hours each. First day, Mathematics and Instruments; second day, Surveying, Design and Construction.

MATHEMATICS.—Answer 3 and only 3 of the following:

1. Given the beam in sketch under a distributed load of 150 lb. per ft., with dead load of 30 lb. per ft. (linear) and carrying two concentrated loads as indicated:



(*a*) Construct shear diagram.

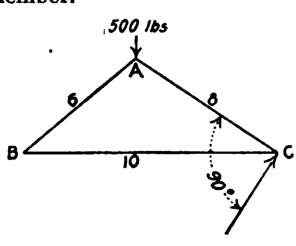
(*b*) Find point of maximum moment and amount of same.

(*c*) Assuming width of 6 in., section rectangular, and maximum allowable fiber stress of 800 lb. per sq. in., what should be the depth of beam?

(*d*) What would be the maximum horizontal shear? (Answer any three parts of this question.)

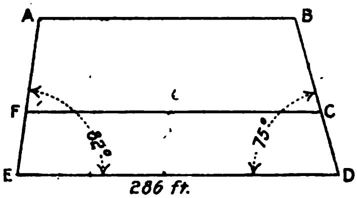
2. (*a*) A ladder 30 ft. long leans against a wall. The ladder weighs 50 lb. A man weighing 150 lb. and carrying 75 lb. weight is $\frac{1}{3}$ way up the ladder. Find reactions of ladder when (1st) it is hinged at top and (2) when it leans against the wall and friction with wall is zero. (Height of ladder top not given by candidate—overlooked probably.)

(*b*) In the pin-connected truss, sketched, find the amount of reaction at "*C*," amount and direction at "*B*" for equilibrium and find stress in each member.



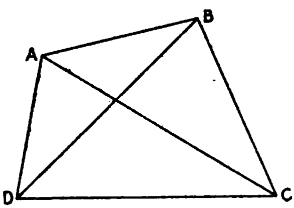
3. In the figure given $B\ D = 42$ ft.
$E\ D = 286$ "
$\angle D = 75°$
$\angle E = 82°$

Find length of frontages $B\ C$, $C\ D$, $E\ F$, and $F\ A$ to hundredths of a foot when area $A\ B\ C\ F$ is twice as large as area $C\ D\ E\ F$. Four-place logs. were supplied.



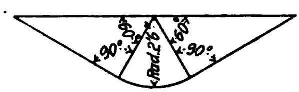
4. Given (see sketch) $D\ C = 1\,200$ ft. and azimuth of $D\ C = 188°\ 40'$; az. of $D\ A = 97°\ 16'$; az. of $D\ B = 130°\ 04'$; az. $A\ C = 30°\ 23'$; az. $B\ C = 76°\ 10'$; find the length and azimuth of $A\ B$.

(Origin and rotation of azimuth not stated; evidently to be determined from sketch.)



5. The sketched figure representing a cross-section of a channel.

(*a*) Find discharge when running full if $C = 120$ (in formula) and slope is 3 ft. per mile.



(*b*) Find size of rectangular section for equivalent discharge if height is $\frac{1}{3}$ of base (running full).

(*c*) If a canal lock gate has 12 ft. of water on one side and 4.2 ft. on the other, what is the pressure on the gate (effective); where is the center of pressure, and what would be the initial velocity on raising the gate 6 inches?

INSTRUMENTS.—Answer three only.

1. A transit telescope is said to be achromatic, have no aberration, must have a flat field (and various other terms). Define each term.

2. Tell how you would care for an instrument to keep it in good order.

3. How would you use a transit to correct for instrumental lack of adjustment in the following cases:

(*a*) Prolonging a line.
(*b*) Measuring horizontal and vertical angles.

4. Given the formula for stadia measurement, $K\ s + d$, show how it is derived and how applied.

5. Draw with pen and ink a longitudinal sketch of a telescope, showing the lenses and other parts; and larger scale sketches to show the relative positions of leases and the shapes of same.

SURVEYING.—Answer three only.

1. How would you proceed to establish a base line in a tract of land 5 miles by $1\frac{1}{2}$ miles, broken by woods, ponds, streams, etc., to a correctness of $\frac{1}{50\,000}$?

2. Having completed that work, how would you fill in your intermediate details? Using a transit reading to 20″, what degree of accuracy would you seek to obtain?

3. Describe how you would set about to obtain 2-ft. contours to plot to a scale of $\frac{1}{1\,200}$.

4. If the above is not according to your idea of procedure, describe in detail what you would do to obtain the necessary information.

DESIGN AND CONSTRUCTION.

1. Write specifications for concrete under water or on a wet subsoil, and give the tests required for each kind of material. This is to test the writer's knowledge of specification writing.

2. Describe what, in your opinion, is the best kind of street pavement. Draw sketches to show the pavement, sidewalks, sewers, drains, water and gas-pipes, etc.

3. A dam is to be built across a valley and the water level is to be 30 ft. above the thread of the valley. The soil consists of 6 ft. of

sandy clay over an indefinite depth of stiff gravelly clay. Make a sketch of an earth or masonry dam you would build to impound the water.

4. How would you drive piles in—
(*a*) Shifty, sandy soil?
(*b*) Gravelly soil?
(*c*) Stiff clay?

What precautions would you take? What length of pile would you use? How would you determine the bearing value of a pile in each case?

5. To design a wooden truss to carry a given load over a given span.

EXAMINATIONS FOR ASSISTANT CIVIL ENGINEERS IN THE UNITED STATES NAVY.

Under date of June 30th, 1904, the Navy Department has issued the following list of rules regarding the examinations:

No person shall be appointed who is less than 23 or more than 28 years of age.

Candidates for appointment shall be examined as to their physical fitness by a board of medical officers of the navy and as to their mental and professional qualifications by a board of such officers as the Secretary of the Navy may designate for the purpose.

The physical examination shall precede the mental and professional, and if a candidate is found physically unfit for appointment he shall not be further examined.

Application for permits to be examined must be made to the Secretary of the Navy, and must be accompanied by testimonials as to character, evidence of American citizenship, evidence of having received a degree in the civil engineering course of some professional institution of good repute, with a record of at least two years' practical experience as a civil engineer. No person shall be admitted who has been examined at any time within one year prior to the date of this examination and failed to meet the professional requirements.

The mental and professional examination will be competitive and in writing and will comprise such subjects as the following: Testimonials and adaptability; English grammar and composition; elementary physics; elementary geology; drawing; arithmetic; algebra; geometry; trigonometry; analytical geometry; differential and integral calculus; applied mathematics, including mechanics of solids and fluids and strains in structures; electricity; construction materials; engineering constructions, such as workshops, steam and electrical machinery, quay walls, wharves, sewers, yard railways, pavements, water distribution, foundations, etc.; surveying (topographical, trigonometrical, and hydrographical) and mapping; instruments, their use and adjustment.

Candidates who pass satisfactorily will be arranged by the board in the order of their relative merit as determined by such professional examination, and appointments will be made in such order, but no candidate will be considered as having passed a satisfactory examination, or be appointed who does not attain a general average of 80%.

The examination will be held beginning August 1st, 1904, at the navy yard, New York, N. Y., and candidates to whom permits may be issued should present themselves before the medical officer or board at that place at 10 o'clock A. M. on that date. The professional examination will occupy about ten days.

PREVIOUS EXAMINATION PAPERS.

SEPTEMBER 6, 1898.

1. Name in full.

2. Whether or not a citizen of the United States of America.

3. When and where born; age in years and months on Sept. 6, 1898.

4. Present address in Washington.

5. Usual address, town, county and state.

6. Statement in detail of engineering instruction received.

7. Tabulated statement of positions held; time in each; detailed description of work.

GRAMMAR.

1. Name the principal marks used in punctuation and give their relative value and uses.

2. What mood most frequently occurs in specifications, and what moods and tenses may be used?

3. "Purchasing pay officers will be furnished with funds for the payment of bills upon requisitions prepared in the office of the Paymaster General, due notice of the drawing of which will be sent to the purchasing officer."

Analyze the above sentence. Parse the underscored words, giving part of speech, number, person, degree, mood, tense, etc., so far as applicable.

4. Give a list of the relative pronouns. Give a list of the prepositions of place and direction. What are the regular endings of participles?

5. Name the most frequently used conjunctions; divide them into classes, and define the characteristics of each class.

COMPOSITION.

Give a description, from 300 to 500 words in length, of some engineering work with which you are familiar, and upon which you have been employed.

ARITHMETIC.

1. Given three buildings 129.2 ft., 191.4 ft., and 295.8 ft., respectively, c. to c. of end posts, in which it is desired that the panel

lengths shall be the same and as long as consistent with this condition, what is the length of panel to be used?

2. The length of a bridge panel is 16 ft. $\frac{1}{32}$-in., c. to c. The depth of truss is 24 ft. c to c. of chords. What will be the center length of an eye-bar providing for a 6-in. pin and a clearance of $\frac{1}{50}$-in. in each eye of the bar?

3. A rectangular prism has a base of 496 by 558 ft. and a height of 186 ft. What is the edge of a cube having the same volume?

4. Find the weight in kilograms of a hexagonal prism of a substance whose specific gravity is 2.3 and whose dimensions are 554.256 mm., on each edge of the hexagon, and 3 m. perpendicular distance between the hexagonal end faces?

5. A square test-piece, originally 8 in. between measuring points, measures 10.35 in. after fracture. What is its percentage of elongation? Its original area was 0.567 sq. in., its rectangular dimensions at fracture are 0.493 in., and 0.562 in. What is its percentage of reduction of area at fracture? What were its original dimensions?

6. What is the cost per cubic yard of finished concrete in place when composed of the following ingredients and worked by the following labor?

16 cu. yd. of silica sea-washed gravel, voids, 37%, at $1.45 per cu. yd.

Sand used in excess to extent of 22%, voids, 43%, at $0.85 per cu. yd. Portland cement used in excess to extent of 16%, $1.96 per bbl. Labor, $\frac{1}{10}$ superintendent at $6.00; $\frac{1}{2}$ leading man at $3.76; two second-class masons at $3.28; four first-class hod carriers at $1.76; two third-class laborers at $1.28, and two fourth-class laborers at $1.04.

Physics.

1. Define the term "hygrometric condition of the atmosphere," and describe a method of determining this condition. What trouble is experienced in compressed-air machinery on account of moisture in the air?

2. How is sound transmitted from point to point, and at what rate in an ordinary occupied hall? Show how you would construct a building so as to prevent sound passing from one room to another. Explain how such a construction attains the desired end.

3. Draw diagrams to show the arrangement of lenses, the axes and the paths of rays of light in an ordinary direct telescope, an

inverted telescope and a field glass. What advantage has the second over the first?

4. Define specific heat, and state which is greater, that of gases at constant pressure, or at constant volume. What work is a measure of the difference? Show how to measure the temperature of a furnace, when the only tools at hand are a pocket thermometer, reading to $\frac{1}{5}°$ between 20° and 120° Fahr., and such articles as can ordinarily be found in a country general store.

5. Draw a heat engine diagram, and indicate at what points entrance and exhaust parts were opened and closed, which curves are isothermal, which are adiabatic, and state upon what the theoretical efficiency of a heat engine depends.

6. An alternating current dynamo delivers 20 amperes under 140 volts at the terminals of a step-up converter, the efficiency of the converter being 68%, what current will be delivered in the line at a voltage of 3 000? Allowing 3% loss in the line up to the terminals of a converter of 85% efficiency, which delivers current to a lamp circuit of 56 volts, what current flows in the lamp circuit? What is the efficiency of distribution from the dynamo terminals of the step-up converter? Describe the principle and construction of the converters. What is the most prominent mechanical difference between the construction of alternating-current and direct-current dynamos?

Geology.

1. Explain the formation of anthracite and bituminous coals, petroleum, and natural gas.

2. What are the principal ores of iron, and about what per cent. of metal does each contain?

3. What is the composition of granite? Of gneiss? Of cyanite?

4. What are artesian wells? Whence is drawn their supply? In what formation would you expect to find artesian water? What is the difference between ordinary driven wells and artesian wells?

5. Explain amorphous and laminated structure in building stones, and state what precautions should be used in laying each kind.

Algebra.

1. Find the value of

$$\frac{\sqrt{(a^2+x^2)}+x}{\sqrt{(a^2+x^2)}-x}, \text{ when } x=\frac{(6-c)a}{2\sqrt{bc}}.$$

2. Divide the product of $x^2 + 3x + 2$, $x^2 - 5x + 4$, $x^4 + 5x^2 - 14$, by the product of $x^2 - 1$, $x^2 - 2$.

3. Extract the cube root of $27x^6 - 27x^5y - 45x^4y^2 + 35x^3y^3 + 30x^2y^4 - 12xy^5 - 8y^6$.

4. Find values of x and y by solving the expressions,

$$x^2 + y^2 = 136 \text{ and } x^2 - 24y = 11.$$

5. Define logarithms and explain their use in extraction of roots and determination of powers of numbers.

Geometry.

1. Using the double-circle method, construct graphically an ellipse whose major and minor axes shall be in the ratio of 3 to 2.

2. Find graphically the center of a given circular arc. Explain the geometrical reason for the method.

3. Bisect the angle A of any triangle $A\ B\ C$ at A, draw a perpendicular to the bisectrix. Prove that the sum of the distances from any point P on this perpendicular to B and C is greater than the sum of $A\ B$ and $A\ C$.

4. Reduce, graphically, the area given to a right-angled triangle of equal area. Give geometrical proof of the method.

5. Prove, geometrically, that the frustum of a pyramid is equal to the sum of three pyramids whose height is the height of the frustum and whose bases are the bases of the frustum, and a mean proportional between them.

Trigonometry.

1. Given, $\sin a = 0.5$; $\cos a = 0.87$; $\sin b = 0.8$; $\cos b = 0.65$. Find $\sin (a - b)$; $\cos (a + b)$. Is the sum of a and b greater or less than 60°? Show how this can be proven.

2. Find the value of $\tan (a + b)$ when $\tan a = 1$ and $\tan b = 1.4$. Is the sum of a and b greater than 30°, greater than 90° and greater than 135°?

3. Given a triangle whose sides are 8, x and y, and whose angles have the following functions:

	Sin	Cos	Tan	Cot
a........................	0.82	0.57	1.43	0.70
b........................	0.90	0.44	2.05	0.49
c........................	0.87	0.48	1.80	0.55

Find the lengths of the other sides.

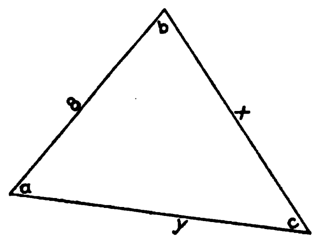


FIG. 1.

4. Represent, graphically, the sine, versed sine, cosine, tangent, cotangent, secant and cosecant of an arc of 60°. Find their values.

5. Prove that in a circle the sine of 90°, the tangent of 45° and the chord of 60° are all equal.

ANALYTICAL GEOMETRY.

1. Prove that every equation of the first degree between two variables is that of a straight line.

2. Given the equation of the circle $x^2 + y^2 = 25$, find the equation of a tangent at the point 4, 3.

3. Deduce the equation of a parabola referred to rectangular co-ordinates, origin at the vertex.

4. Give the equation of the equilateral hyperbola referred to its asymptotes, these co-ordinate axes being rectangular. Where is this equation of practical use?

5. Given the general equations of line and circle:

$A\,x + B\,y + C = 0$, and $x^2 + y^2 + A\,x + B\,y + C = 0$.
prove analytically that the common chords of three intersecting arches intersect in a common point.

DIFFERENTIAL CALCULUS.

1. Differentiate $a\,x^2$ and prove the result.

2. Differentiate $\frac{a}{x^2} \log A\,x$.

3. A square piece of sheet metal is to have a square cut out from each corner, and the four projecting flaps are to be bent up so as to form a tank. What must be the side of the part cut out that the volume of the tank may be a maximum.

Integral Calculus.

1. Find $\int (a - 4\,x)^2\,d\,x$.

2. Deduce the general formula for the area of a plane figure in polar co-ordinates. Find the area of a circle by this formula.

Instruments.

1. Draw a diagram which will show the principal features of a plain transit. Give the adjustments in order and describe them.

2. Draw a diagram which will show the principal features of a Y-level. Give the adjustments in order and describe them.

3. Describe the surveyor's compass and state in what important respect the mariner's compass differs from it.

4. Having no leveling instrument or leveling tool at hand, construct a level of sufficient accuracy for ordinary drainage work.

Drawing.

1. Draw a plan and two elevations of a pile of blocks as follows: The lower 3 by $1\frac{1}{2}$ by $\frac{1}{2}$ in., lying on the horizontal plane, its long edge making an angle of 30° with the vertical plane; the second of the same section, but 1 in. shorter, lying on the first and making with it an angle of 45°; the third, a rhomboid, with largest edge 1 in., lying upon the second. Show the shade lines, the light rays making an angle of 45° with both the horizontal and vertical planes. Show shadows.

2. Draw in isometric projection a cube of 8 in. edge. Show a square hole with 1 in. edge through the middle of the cube from top to bottom. Show circular holes 1 in. diameter through the cube from the centers of the other faces. Show recess 2 in. diameter and $\frac{1}{2}$ in. deep around hole on left-hand side. Show square collar $\frac{1}{2}$ in. high, 1 in. internal diameter and 2 in. external diameter, around hole on right-hand face.

3. Make a finished tracing of either 1 or 2.

4. From the drawing furnished, state each element and its function in the machine.

5. Make a finished topographical map from the sketch furnished.

Surveying.

1. Fill out the notes given below; correct the readings for curvature and refraction, and find the elevation of the second bench mark:

Sta.	Dist. fr. level.	B. S.	H. I.	F. S.	Elev.
B. M., No. 1.............	100 ft.	4.522	......	......	25.373
A.	500 ft.	.....	......	11.167	......
A.	75 ft.	1.277	......	......	......
B. M., No. 2.............	450 ft.	.....	......	7.423	......

All readings are in feet.

Describe method of making and locating bench marks in a wild country.

2. A bench mark on shore reads 24.96 ft., referred to Cairo datum; this datum is 21.26 ft. below mean Gulf level; the zero of a standard tide gage is 20.91 above mean Gulf level. Starting from the bench mark, set a tide gage with Gulf level for zero. Tide gage reads 3.7 ft.; reduce a sounding of 59 ft. to zero of the standard gage.

3. Show how to make a topographical survey of the hill indicated (Fig. 2), and determine the number of cubic yards it contains. Assume any elevations and distances you may choose.

FIG. 2.

4. Having a property located on a river front, as indicated (Fig. 3), locate soundings and the course and rate of current, having only one transit. Graduate a sounding line for use on the above work. Describe a float for use in ascertaining the discharge of a stream.

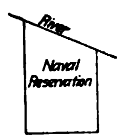


FIG. 3.

5. Having a field bounded by the lines passing between the points *A, B, C, D, E, F, G, H, I, J* (Fig. 4), all of which are about 5 ft. above the level of high water in the river; dense woods in the areas indicated; a hill 35 ft. high; a wall 20 ft. high; a swamp and a slough in the indicated positions; and the points *I* and *J* marked by piles in the river; show how lines would be traced and their

lengths and directions determined. The branch of the slough where it is crossed by the lines *H I I J* and *J A* are about 700 ft. long.

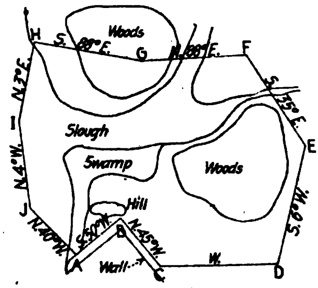


FIG. 4.

GRAPHICS.

1. Given a beam 25 ft. in length, and weighing 150 lb. per ft., with weights distributed as shown in sketch (Fig. 5); find graphically the amount and location of the greatest bending moment. Also show graphically the shear. Find both analytically.

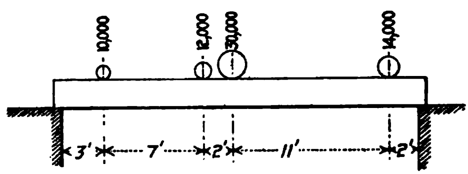


FIG. 5.

2. Determine graphically the stresses in the members of the roof truss shown in diagram (Fig. 6), the load, including the weight of the roof, to equal 45 lb. per sq. ft. Trusses to be 24 ft. c. to c.

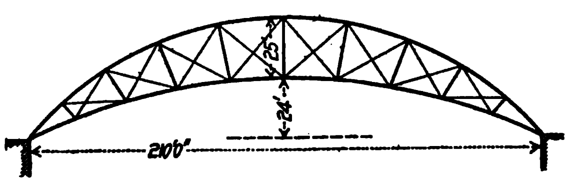


FIG. 6.

GENERAL PRINCIPLES OF MECHANICS.

1. A train's speed is 45 miles per hour. Its wheel base, uniformly distributed, is 8 ft. The curve upon which it is running is of 1 000 ft. radius. The load upon each axle is 14 000 lb. Ties are spaced

2 ft. centers. The side resistance of a spike is 1 200 lb. How many spikes are required in each tie to make the factor of safety 4?

2. Show how to find, experimentally, the center of gravity of a shape of irregular section (Fig. 7), where the end is cut in a plane normal to the longitudinal axis of the piece and can be easily reached for inspection and measurement. Let the section be that shown in the diagram. Find, also, the center of gravity of this section analytically.

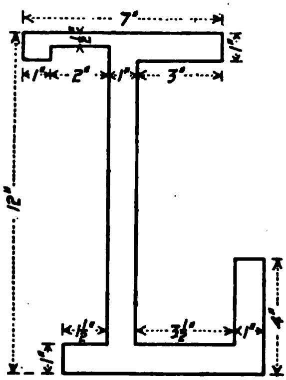


FIG. 7.

3. Find the moment of inertia of the above section about an axis through the center of gravity, and parallel with the long edge.

4. Given a pile which has been driven 40 ft., and which is 6 in. in diameter at the lower end and 13 in. at the surface of the ground; what is the frictional resistance per square inch of the pile if the next blow of a 3 000-lb. hammer, falling freely 20 ft., sinks the pile 1 in.?

5. A car starts down a grade of 1%. What is the coefficient of friction? What kinds of friction exist, and at what points? Which kind is the greater in this case?

MECHANICS OF FLUIDS.

1. Find entire pressure and center of pressure on a trapezoidal gate, the upper edge of which is 80 ft. long; the lower edge 65 ft.; the depth of water being 28 feet.

2. A wooden sphere, the diameter of which is 8 in. and the specific gravity 0.75, is placed in water. To what depth will it sink?

3. Give the Chezy formula; explain the meaning of all the terms entering into it; state what modifications, if any, you would make in its use.

4. Make a diagram of and explain the principle of action of the hydraulic ram.

5. Explain the purpose, principle and action of an accumulator.

Cranes.

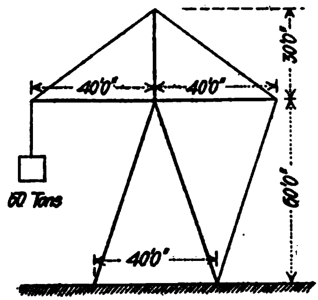


Fig. 8.

1. Determine the stresses in the members of this crane (Fig. 8), both analytically and graphically.

Chimneys.

1. A steel chimney 150 ft. high and 9 ft. in external diameter is to be constructed. What number of $\frac{3}{4}$-in. rivets will be required in the horizontal joint 30 ft. above the ground, the wind pressure being assumed at 40 lb. per sq. ft.?

Constructional Materials.

1. Provided Indiana limestone and the commonly used brownstone cost the same per cubic foot, which would be preferable for ashlar work in the vicinity of New York or Boston? Why?

2. For polished decorative work on buildings, what stone would you use for outside work? What for interior work? For what work would you use bluestone?

3. How are bricks classified? What kind would you use for house fronts? What in boiler settings? What in steel chimney linings? What in pavements?

4. What cement would you use where it is desirable to have as great strength as possible? What where less strength is required and economy in first cost is essential? What tensile strength would you expect each to show in test briquettes at the end of seven days? What is the difference in composition and action of these cements?

5. Of what is concrete made? What are the proportions commonly used? How should it be mixed? How put in place? On what does its value depend? What precautions should be taken in its use?

6. What are the principal kinds of glass used in ordinary building construction? What would you require for a six-light sash, 12 by 15 in. panes, to be used in a good store house? What glass would you use in good skylights? What are the standard sizes of tin roofing plates? Is IC or IX the heavier plate? How should tin be laid on a steep roof? How on a roof of little pitch?

7. Describe the characteristics of cypress, yellow pine, white pine, hemlock, spruce, poplar, ash and oak.

8. State what should be used for each of the following purposes: Norfolk bearing piles; Boston bearing piles; wales; first-class floor beams and joists; door and window trimmings; office and house wainscoting; sheathed partitions, and wooden ceilings.

9. How does prime inspection differ from mercantile inspection?

10. What is the composition of the best paints for wood, iron and tin surfaces? What would be used on stained uncarpeted floors? What on hardwood trimmings to show the natural color and grain?

11. Name the principal metals used in engineering work and give their range of strength in tension. Name the common elements occurring in metals of engineering and describe their effects upon the physical properties.

12. What is galvanized iron? In what form is it commonly used for roofs and sidings of buildings? In what for gutters and downspouts? Thickness commonly used? Usual sizes of manufactured sheets? Upon what does its durability depend?

13. In what form is copper used in building? What are its advantages over tin or galvanized iron? What two kinds are used? What are the characteristics of each?

14. What considerations of theory and practice determine the sections of the usual commercial forms of structural iron and steel?

Engineering Construction.

1. Draw diagrams of sections of the following floors: End construction, hollow tile; side construction, porous terra cotta; buckle plates; slow-burning mill construction.

2. Describe the construction of each of the above floors, and its action under fire and water and under repeated blows.

3. Design a flight of stairs, 4 ft. wide, between two floors 14 ft. apart vertically; strings to be of steel and treads of yellow pine.

4. In a 100-ft. plate girder, having continuous flange angles and a web consisting of five plates, explain why holes may mismatch after being correctly laid off and accurately punched. How may this difficulty be avoided?

5. What are the requisites of good machine riveting? Why is machine riveting preferred to hand riveting? How can loose rivets be detected?

Pavements.

1. Describe Telford and Macadam roads. Make sketches of cross-sections, showing the construction of each. What amount of crowning would you give? What is the best stone to use and why?

2. Describe the construction of the best quality of granite block paved streets, of brick paved streets, and of asphalt paved streets.

3. Under heavy traffic, can a wooden pavement be used economically? If so, how heavy must the traffic be? Show the best construction for wood pavements.

Dry Docks and Quay Walls.

1. Draw the transverse section of a concrete dry dock 90 ft. wide on the floor and 39 ft. deep, with blocks 4 ft. high and top of blocks 30 ft. below high water. Determine the thickness of concrete floor which will be required if water under bottom of dock is in connection with that outside the gates and if the weight of the floor is to be depended upon to balance the existing pressure. Show a method of building a floor in a dock of this width which will be more economical.

2. Sketch a section through a floating dock to take ships drawing 18 ft. of water.

3. Design a quay wall to be built under the following conditions: Mean rise and fall of tide, 12 ft.; extreme rise and fall, 19 ft.; bottom slope, about 1:10, running out to depth of 35 ft. at extreme low water; character of bottom, sand and indurated gravel into which timber piles can be driven by impact about 6 to 8 ft.; the teredo is very bad, destroying timber in from one to three years; timber plentiful; material for fill, sand and gravel from dredging or from the neighborhood; broken stone obtainable from quarry near by; depth of water alongside to be at least 20 ft. at extreme low water, and 30 ft. at a distance of 20 ft. from the wall; dredged slopes have stood for years in deep water at 1 on 1.

WHARF.

1. Given conditions as shown in the subjoined sketch (Fig. 9), design a wharf alongside of which ships 400 ft. long, drawing 28 ft. of water, can lie.

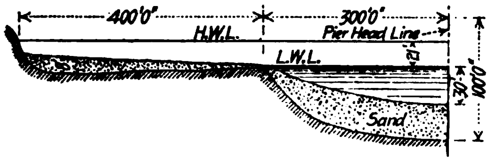


FIG. 9.

BOILERS, ENGINES AND ELECTRIC PLANT.

1. Draw a longitudinal diagram of a brick boiler-setting for a horizontal return tubular boiler in which the fire-sheet is extended beyond the head tube-sheet to form the bottom and sides of the smoke connection.

2. State what ratio should exist between the area of grate and the area over bridge wall. What is a good ratio of heating surface to grate area?

3. Where should hand and man-holes be located? Draw sketch of man-hole cover, and show how it is fastened in place to insure a steam-tight joint. How many back-stays should be provided for an 18-ft. tubular boiler, 60 in. in diameter?

4. Make a diagram of and explain the principle and action of an injector on a steam boiler. Where is the exhaust pump located in a jet condenser, and why?

5. Give essential differences between engines for mills and for electric light plants.

6. Draw a section of a brick chimney 100 ft. high, having a flue 4 ft. square, on a concrete foundation placed upon a good bed of gravel which is 50 ft. thick.

7. Illustrate by diagram the three-wire system of electric distribution. State what voltage you would specify for generators, motors, arc lamps, and show how they would be connected in the same three-wire system. Explain the use of feeders.

MASONRY AND FOUNDATIONS.

1. What are footing courses and what purpose do they serve? Draw diagram showing stone footing courses for a 32-ft. wall, and brick footing courses for a 24-ft. wall.

2. Design a flying buttress to give a clear space of at least 12 in. wide by 15 ft. high between it and the building, and to take the thrust of 125 000 lb. at an angle of 45° with the horizon at 25 ft. above the surface of the ground.

3. Design an abutment for a double-track railway bridge to span a street 60 ft. wide, to give a clear headway of 15 ft. and to be located on a good gravel foundation.

4. Draw diagram of and explain the construction of a foundation such as is much used in Chicago to support a heavy steel frame building on a light compressible soil.

5. Design a foundation for a column to be placed at *A* (Fig. 10) to support a load of 350 000 lb.

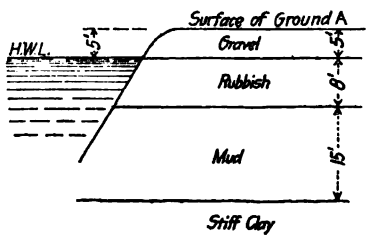


Fig. 10.

Yard Railways.

1. Draw a diagram to show a system of construction when a girder rail is used. What objection is there to the use of girder rails in the streets of navy yards where ordinary freight cars can be hauled over them?

2. Show a system of track construction in which T-rails are used in paved streets in such a way as not to interfere with the ordinary wheeled traffic.

3. Put a light curve in a T-rail track without the use of a rail bender.

4. Draw diagram of a turnout, using a safety switch and bolted frog.

5. Illustrate by diagram and describe apparatus necessary to transfer freight cars from floats to yard tracks, the coping level being 5 ft. above mean high water, and the mean rise and fall of the tide being 6 ft.

Water Distribution and Sewers.

1. A yard supply is drawn from springs flowing, approximately, 100 000 gal. per day. Design a well so that this entire flow can be utilized by a pump working 8 hours per day. Sketch plan and section of well.

2. Given a yard supply as in the above question; design a steel tank or tanks to hold 500 000 gal., sketching plan, section and elevation, and showing foundation on slightly compressible soil, thickness of metal, size and spacing of rivets. Give also details of pipe connections.

3. The above tank or tanks being located on a hill 200 ft. above the working portion of a yard and three-quarters of a mile distant, what thickness would you give to the cast-iron distributing mains, from tank to tide-level, for 4-in., 6-in., and 8-in. pipe?

4. A large, circular city sewer, 6 ft. in internal diameter, discharges into the water fronting a navy yard. Design a diverting sewer of semi-circular section, with pile and timber foundation, to carry the sewage through the yard to its boundary. The sewer to be strong enough to support the passage over it of the heaviest weights likely to be met with in navy yards. The junction with the old sewer to be arranged to permit the use of the latter for storm waters. What change in bottom and foundation would you make where it passed over a compact bed of gravel of considerable thickness?

5. Describe methods of giving grade, and the laying of pipe sewers.

EXAMINATION QUESTIONS FOR EXAMINATION HELD DECEMBER, 1900, TO FILL VACANCIES IN THE CORPS OF CIVIL ENGINEERS, U. S. NAVY.

Personal Data.

(*a*) Name in full. (*b*) Whether or not a citizen of the United States of America. (*c*) When and where born. Age in years and months on December 17, 1900. (*d*) Local address while taking examination. (*e*) Usual address, town, county and state. (*f*) Statement in detail of engineering education received. (*g*) Tabulated statement of positions held, time in each, detailed description of work.

Drawing Materials Which Should Be Brought In by Candidates.

Drawing board, about 15 by 20 in.; T-square; triangles, 30° and 45°; thumb tacks; a plain set of instruments; drawing pencils, mapping pens; red and black drawing inks; scales; drawing paper, white and detail, of each about 4 sq. ft.; tracing cloth, about 4 sq. ft. All drawings must be made to trim to 8½ by 14 in., with a proper margin for binding.

English Composition.

Write a letter to the Board, about two pages in length, stating clearly and concisely what in your opinion is the most desirable branch of the civil engineering profession to be followed in civil life and why.

English Grammar.

1. Correct the following sentences if necessary and give reasons: (*a*) Were it true that a sufficient strata of clay exists at that level Smith and myself should have the information. (*b*) It is they whom our thoughtless friend would offend if he was present at the time. (*c*) To myself it has occurred that were he in a syndicate he would neither be so outspoken or so bitter in his opposition against such organizations. (*d*) Though he may try to impress on his auditors his own wide experience, he only succeeds in earning for himself the ridicule of those of even superficial education. (*e*) Well as he appears since his confinement with typhoid, he always complains of feeling badly.

2. Analyze the following sentence: Though he served or tried to serve Russia as faithfully as he had served America, the conditions he encountered were not adapted to his temperament.

3. Give a tabular synopsis of the voices, moods and tenses of verbs, and illustrate by the first person singular of each of the following: Begin, get, eat, draw, bring.

4. State the rule for the usual formation of the plural of nouns and illustrate by three examples. State the plural of the following: Mouse, deer, man, woman, foot, swine, goose, vermin, box, cow, means, potato, wolf, ox, chimney, fairy, elf.

5. Classify and decline the following pronouns: I, whoever, that, you, it, myself.

Arithmetic.

1. Find the least common multiple of the following numbers, giving all work: 668304, 2100384, 12285.

2. Below are given the rod readings at the corners of 10-ft. squares taken over a portion of a borrow pit. Determine the amount excavated in cubic yards and also the side of a square bin 10 ft. deep which will just contain the excavated material. The rod readings are in feet.

10	6	3	2	7	4	5	10	6	7	3
4	4	5	6	3	7	5	6	4	5	4
7	3	6	10	12	7	9	10	5	2	
	6	8	16	20	25	12	8	4	6	
	5	8	5	13	24	14	6	7		
		4	2	9	11	7	3	5		
		10	6	4	3	5	6			
				5	2	4	8			

3. Find the partial and total feet, board measure, in the following bill of timber: 71 pieces 12 in. $\times$ 14 in. $\times$ 22 ft.; 16 pieces 12 in. $\times$ 12 in. $\times$ 30 ft.; 27 pieces 10 in. $\times$ 12 in. $\times$ 20 ft.; 116 pieces 6 in. $\times$ 8 in. $\times$ 18 ft.; 317 pieces 3 in. $\times$ 14 in. $\times$ 24 ft.; 18 pieces 3 in. $\times$ 10 in. $\times$ 22 ft.; 74 pieces 2 in. $\times$ 8 in. $\times$ 16 ft.; 506 pieces $1\frac{1}{2}$ in. $\times$ 12 in. $\times$ 24 ft.; 117 pieces $1\frac{1}{4}$ in. $\times$ 6 in. $\times$ 16 ft.; 221 pieces 3 in. $\times$ 4 in. $\times$ 18 ft.

4. Determine the cube root of the following, giving all work: 57.825915363.

Algebra.

1. Reduce to its lowest terms:

$$\frac{8\,a^2\,b^2 - 10\,a\,b^3 + 2\,b^4}{9\,a^4\,b - 9\,a^3\,b^2 + 3\,a^2\,b^3 - 3\,a\,b^4}.$$

2. Find the value of:

$$\frac{b\,c\,d}{(a-b)\,(a-c)\,(a-d)} + \frac{c\,d\,a}{(b-c)\,(b-d)\,(b-a)} + \frac{d\,a\,b}{(c-d)\,(c-a)\,(c-b)} + \frac{a\,b\,c}{(d-a)\,(d-b)\,(d-c)}.$$

3. Extract the cube root of:

$$27x^6 - 27x^5y - 45x^4y^2 + 35x^3y^3 + 30x^2y^4 - 12xy^5 - 8y^6.$$

4. Solve the following equations:

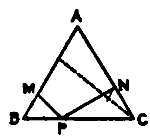
$$3x^2 + 165 = 16xy \qquad 7xy + 3y^2 = 132$$

5. Expand to six terms:

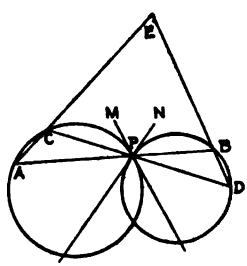
$$\frac{1}{(2a - 3x)^3}.$$

Geometry.

1. If from a variable point P in the base of an isosceles triangle $A\ B\ C$, perpendiculars $P\ M$, $P\ N$ to the sides are drawn, the sum of $P\ M$ and $P\ N$ is constant and equal to the perpendicular from C upon $A\ B$. See the subjoined figure.



2. Demonstrate that if through P, one of the points of intersection of two circumferences, any two secants $A\ P\ B$ and $C\ P\ D$ are drawn, the straight lines $A\ C$ and $B\ D$ joining the extremities of the secants, make a constant angle E, equal to the angle $M\ P\ N$ formed by the tangents at P.



3. Find the lateral area of a frustum of a right cone of altitude 10, diameters of bases 8 and 12, and prove the formula used.

4. Prove that in a regular tetrahedron, three times the square on an altitude equals twice the square of an edge.

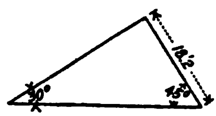
5. Define spherical excess and prove that a spherical triangle equals a lune whose angle is half the spherical excess on the triangle.

TRIGONOMETRY.

1. Express all the other trigonometric functions in terms of the sine and prove the expressions.

2. Develop the expressions for the sine of the sum and the sine of the difference of two angles. Also develop

$$\text{Sine } (a + b + c).$$



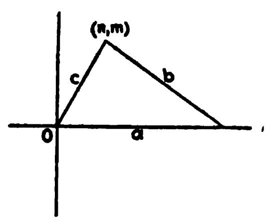
3. Find the missing values of the angle and sides in the triangle shown and derive the formula used to obtain the sides.

4. Give Napier's rules of circular parts and illustrate the same by a diagram.

ANALYTICAL GEOMETRY AND CALCULUS.

1*a*. Find the equation of the straight line which passes through two given points.

1*b*. Demonstrate that the straight lines drawn from the angles of a triangle to the middle points of the opposite sides meet at a point. Use the subjoined figure and notation.



2. Deduce the general polar equation of the circle and show its form when the center is at the pole.

3. Demonstrate that from any external point two tangents can be drawn to an ellipse, and determine the equation of the chord of contact.

4. Discuss by differential calculus the curve represented by

$$y = \frac{a^2 x}{a^2 + x^2}.$$

5. Find by integration the area between the parabola

$$y^2 = ax$$

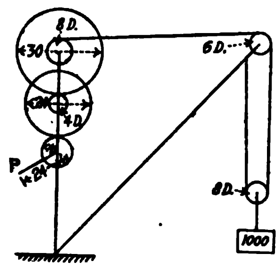
and the circle

$$y^2 = 4ax - x^2.$$

Show all work.

Physics.

1. Neglecting friction, find the power to be applied at the end of the crank, and also the rate of hoisting the load when the crank is revolved four times per minute.



2. Draw a diagram of essential elements of a phonograph, describe the method of using the instrument, and give the principles upon which its operation depends.

3. Describe one of the more common forms of commercial ice machines, and give the principles and cycle of operations.

4. Describe the phenomena of the rainbow. Show when they may occur, and sketch a diagram showing the paths of rays of light from the sun to the eye of the observer.

5. Draw diagrams of a reflecting galvanometer and a Wheatstone bridge. Show how to use the instruments to find the resistance of a coil whose resistance is greater than the combined resistance of the bridge.

Geology.

1. What agencies are now at work to modify the structure of the earth crust? Explain the formation of soil. Why does soil accumulate more rapidly on lowlands than in mountainous regions?

2. State the origin of granite, quartz, clay, limestones, corals, sandstones, quartzite, coal, lignite.

3. What law governs the increase of erosive power with velocity in running streams? Give your authority.

What is an estuary? Give mode of formation.

What are faults? How caused? What is their effect in the exploitation of mines? Give illustrative diagrams.

4. Explain the origin of icebergs.

State the principal stratified building stones. What precautions should be taken in laying them in a structure?

What is the most common igneous rock used in construction?

What is the most common structure of basalt? What is the generally accepted cause of this formation?

5. What is the source of aluminum, its method of extraction, its principal alloy, its most notable characteristics, the principal drawbacks to its general use?

What is galena? Malachite?

What is the composition of hematite, magnetite, limonite, pyrites?

SURVEYING.

1. Find the area of the following piece of ground, determining the length of the missing course and also its bearing, giving the latter by means of its tangents:

a to *b*, N., 20 ft.; *b* to *c*, N. 60° E., 500 ft.; *c* to *d*, E., 300 ft.; *d* to *e*, S. 45° W., 400 ft.; *e* to *f*, S. 15° E., 400 ft.

2. Give day and night methods of determining the true meridian. State all instruments, tables, etc., required for the work, explain in detail the methods to be employed, and the corrections to be applied to observations.

Discuss the relation between magnetic and true meridians as to time and locality.

3. Give detailed description of the method of making a hydrographical survey of a tidal river at least 500 ft. across.

4. Given a level in perfect adjustment, describe in detail the method to be employed in running an accurate line of levels, several miles in length, over an irregular country. State the precautions to be taken and the corrections to be applied for climatic and other reasons.

5. Describe the method you would employ in making a topographical survey of a small area of great value to be improved at a cost which depends largely upon the conformation of the surface.

Describe the method you would employ in making a topographical survey of a large area of forest, swamp and lake, the value of the property being relatively small.

INSTRUMENTS.

1. Draw a diagram which will show the principal features of a plain transit. Give the adjustments in order, describe them, and illustrate by diagrams.

2. Draw a diagram which will show the principal features of a Y-level. Give the adjustments in order, describe them, and illustrate by diagrams.

3. Describe the stadia, illustrate by diagram, show its use, and deduce all formulæ needed for its operation.

4. Describe the construction and use of the surveying sextant and illustrate by diagram.

Show how the three-arm protractor is used in plotting locations determined by sextant angles.

5. Draw a diagram of a mercurial surveying barometer, showing all essential details for adjustment; describe proper methods of transportation and use of instrument, and state what tables you would use in working up readings.

DRAWING.

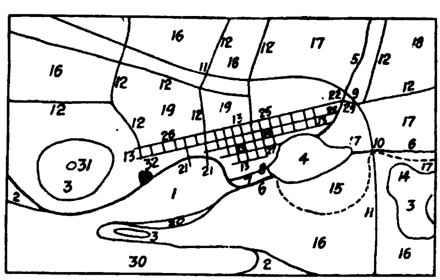
1. Draw plan, one elevation and section parallel to vertical plane of the following:

A hexagonal block, with side 2 in. and height the same, stands on the horizontal plane with its centre 3½ in. from the vertical plane. Through this block is a circular hole 1½ in. in diameter. Standing with the center of its base to the left and in a direction from the center of the block which makes an angle of 30° with the vertical plane, is a right cone with base 3 in. in diameter and height 5 in. Show shade lines, shades and shadows, the rays of light coming from the left and making an angle of 45° with both horizontal and vertical planes.

2. Make a finished tracing of the above drawing.

3. Make a perspective of the above blocks with shades and shadows.

4. Make a finished topographical map from the accompanying sketch. Reference numbers as follows:

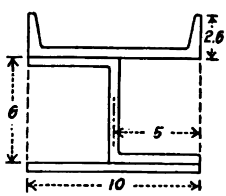


1 bay.
2 sand.
3 hill.
4 pond.
5 creek.
6 river.
7 canal.
8 lock.
9 bridge.
10 drawbridge.
11 railroad.
12 roads.
13 streets.
14 quarry.
15 swamp.
16 woods.
17 grass.
18 orchard.
19 cultivated land.
20 marsh.
21 piers.
22 railroad station and telegraph office.
23 post-office.
24 court-house.
25 church.
26 blacksmith's shop.
27 woolen mill.
28 sawmill.
29 grist-mill.
30 anchorage.
31 light-house.
32 hotel.

Mechanics of Solids.

1. In the sketch shown the plate is ½ in. thick. The area of the 10-in. 15-lb. channel is 4.46 sq. in. Its c. of g. is 0.639 in. from back of web. Its moment of inertia parallel to the web is 2.30 and perpendicular to web is 66.9. The area of the 6-in. 15.6-lb. Z-bar is 4.59 sq. in. Its moment of inertia, neutral axis through c. of g. parallel to web, is 9.11 and perpendicular to web is 25.32.

Find the center of gravity of the combined section, its moment of inertia and radius of gyration about a pair of rectangular axes, parallel and perpendicular, respectively, to the web of the Z-bar and passing through the c. of g. of the section.

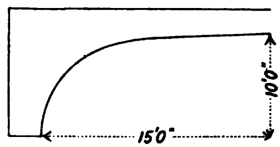


2. A medium steel shaft, 10 ft. long and 4 in. in diameter, has a gear wheel 6 ft. in diameter keyed on one end. Using ordinary factors of safety for running shafting, what is the greatest horsepower which can be transmitted? Give values for ultimate strength and safety factor used.

3. A standpipe, 80 ft. high and 30 ft. diameter, is constructed of soft steel plates, with lapped joints. What must be the thickness of the bottom course of side plates, using the customary values for the safe strength of the material? Seven-eighths-inch rivets being used, what must be the spacing of rivets in vertical seams in this course?

4. Design a reservoir wall of Portland cement concrete, the inner face to be vertical and the height to be 20 ft., the outer face to be uniformly battered; water level, 2 ft. below top.

5. Illustrate by means of the following diagram the method and principles of design of a stone arch, supplying any further lines necessary for the purpose.



Mechanics of Fluids.

1. Find the total pressure on the surface of a material cylinder of length 3 ft. and diameter 2 ft., its axis parallel to the surface of the water, in which it is immersed to a depth of 10 in. from surface to axis.

2. Explain the turbine and impulse wheels; make a diagram of each and show when each should be used.

3. Give the formula for the flow of water through a pipe $\frac{3}{4}$ full and discuss it.

4. Let h be the total head on a pipe, h' the head lost in entrance, h'' that lost in friction, h''' that lost in valves, bends, etc.; deduce a formula for velocity and one for discharge from a circular pipe.

5. Derive and discuss the formula for the flow of water through a rectangular vertical orifice, its upper edge being coincident with the surface; a rectangular vertical orifice, its upper edge parallel to but below the surface of the water; a circular vertical orifice below the surface of the water.

Pavements.

1. Make sketches and describe in detail the design and construction of an asphalt paved residence street 120 ft. wide between house lines.

2. Make sketches and describe in detail the design and construction of a granite block paved street 50 ft. wide between store houses having the receiving and delivering doors on both sides of the same. Include a crossing.

3. Make sketches and describe in detail the design and construction of a brick paved street 80 ft. wide in a retail district, the street

to have a double-track for street cars. Width to be between store fronts.

4. Make sketches and describe in detail the design and construction of a macadam park drive 40 ft. wide.

5. Make sketches and describe in detail the design and construction of a gravel country road through a clay region, the road to be of small cost and sufficient for a small amount of traffic in heavy wagons.

Boilers and Engines.

1. Give the ordinary commercial rules for rating the horse-power of boilers.

What quantity of steam is required per horse-power per hour in the best quality of condensing engines of about 500 HP.?

2. Would a chimney 60 ft. high, having a flue 4 ft. in diameter, be equally good for anthracite and bituminous burning furnaces? If not, why not?

Give the essential features to be considered in the design of a furnace for the burning of anthracite coal and of one for a bituminous coal having a large percentage of volatile hydrocarbons.

3. Sketch the following different kinds of boilers: Return tubular, vertical fire tubular, water tubular, Scotch, locomotive.

State the advantages and disadvantages of each, describing, among other things, wrought iron, cast iron, cast steel, flowed steel and wrought steel, corrugated flues, straight tubes and curved tubes.

4. What elements should be included in the specification for an efficient 500-HP. cross-compound condensing engine direct-connected tc two electric generators used for electric-light service?

5. Make diagrams of and describe jet and surface condensers, give the advantages and disadvantages of each, state the auxiliary machinery required in connection with condensers, and state what you know of central condensers for a plant of several engines.

Structures.

1. Design a machine shop 300 ft. long and 90 ft. wide, walls 30 ft. high, benches and belted tools to be placed on the sides of the shop, the central bay to be a single story served by a traveling crane and having a railroad track and floor for heavy, movable tools. Materials are to be steel, brick, wood, concrete and slate. Foundations supposed to be in a soil which will sustain 1 000 lb. per sq. ft. at a depth of 1 ft. and 2 000 lb. at a depth of 10 ft., water met at a depth of 5 ft. Weight of 250 lb. per sq. ft. is to be provided for on the

second floor and 500 lb. per sq. ft. on the lower floor. Make free-hand sketches of plan, longitudinal and cross-sections.

2. Show full details of second floor using expanded metal or similar construction with fireproofed wood floor.

3. Show detail of floor in central bay to support work under construction and electrically-driven movable 15-ton tools.

4. Show details of a double sash, check-rail, box-frame window and the setting of the same in the side wall.

5. Show in detail and describe fully the construction of a tight skylight 6 ft. by 10 ft. in one side of the roof.

Masonry and Foundations.

1. Discuss pile foundations in mud, quicksand and clay. Give rules for the determination of the bearing power of piles driven by ordinary pile-driver and by steam-hammer. Under what conditions does each give best results? Why?

2. Under what conditions would you use screw piles and piles with disks? Describe the method you would use to put each kind in place. Design the screw end of an 8-in. steel pile to be placed in 30 ft. of water, seated in a sandy bottom, and to support 150 000 lb.

3. Given a machine shop on compressible soil, to supply a foundation for a 15-ton steam-hammer. Show how you would design the foundation without the use of wooden piles.

4. Give specification for laying best quality of stone masonry; also for a brick wall with ashlar front.

Show how terra-cotta caps and lintels should be laid and secured.

5. Give specification for Portland cement concrete to be used for a building foundation. Give specification for the plastering of a room with regular three-coat work.

Dry-dock.

The site for a dry-dock having been selected and test piles driven, it is found from the latter that the penetration of the piles in the bottom of the dock will be about 40 ft. in sticky mud, the penetration under the last blow of a 3 000-lb. hammer falling 25 ft. being 1 in.

Sketch out, free-hand, a design for a concrete dry-dock with granite protective trimmings for all necessary points, the dock to be 600 ft. long on the floor from the gate-sill to first altar at head of dock, with a width sufficient for a battleship of 72 ft. 6 in. beam. It is desirable to use due economy in the design, and to make the fullest

use possible of the piles in conformity with good practice. A caisson gate will be used, but no details of it will be required.

Materials of Construction.

1. Describe fully the manufacture and characteristics of high-grade building brick, Roman brick, sewer brick and terra-cotta tile.

2. Describe the difference between Rosendale and Portland concretes. Give the conditions under which you would use each kind.

What is the method you would employ to find the best proportions to be used in a concrete composed of broken stone, gravel, sand and cement?

3. In the case of a granite inverted arch resting on a heavy concrete bed in the bottom of a dry-dock, state how you would cut and bed each block.

Give a specification for high-grade roofing slate.

4. Describe by diagram the method of cutting quartered oak from logs; also edge grain flooring.

Give merchantable inspection for yellow-pine boards and dimension lumber.

5. Describe the characteristics and give some of the principal uses for long-leaf yellow pine, loblolly, spruce, white pine, white oak, cypress.

6. Describe briefly the manufacture and characteristics of acid open-hearth steel, basic open-hearth steel, Bessemer steel and cast iron.

7. Describe in detail the manufacture by the open-hearth process of a modern structural shape, beginning with the taking of the ore from the mine.

8. Describe lead and zinc paints. Give the proper methods and proportions of mixing the manufactured article with oil and dryers for inside and for outside work.

9. Describe the best paints and other materials for use in protecting steel exposed to air and gases in a machine shop, in a water tower and trestle, and in a steel pier in a tideway.

10. Discuss slate, tin and copper for use as a roof covering. Describe the methods to be used in laying each kind. Give a specification for good roofing tin.

Railroads.

1. What is the degree of curvature of a railroad track? Show how a curve can be staked out by the method of tangents. Describe

in detail the usual method of staking out 475 ft. of a 4° curve, starting at station 625-50, using a transit and a 100-ft. tape.

2. Describe in detail the method and work necessary to lay a side-track from a main line already in place. Draw diagrams of plans and cross-sections of the parts.

3. How short a radius can be safely used in yard tracks of 4.7 ft. gage? What limits the radius in this case? What is the best radius to use in industrial tracks of about 21 in. gage as usually built in this country?

4. Make cross-sections of T and girder rails and discuss their advantages in street track work.

5. Indicate in detail the rolling-stock necessary for a large navy yard, to include all necessities for the transportation of materials, for making general and special repairs, and for convenience and economy in all work which may be brought within reach of the track system.

Wharf.

Design a timber-pile pier 80 ft. wide, 600 ft. long, for the dockage on both sides of ocean steamships. Depth of water at mean low water, 27 ft.; mean rise of tide, 4 ft.; bottom material, river mud to depth of 80 ft. Sketch details and main cross-sections of wharf, ready for commercial use. Give necessary formulæ used in the design.

Quay Wall.

Design a quay wall to be built under the following conditions:

Mean rise and fall of tide, 5 ft.; extreme rise and fall, 9 ft.; bottom slope, about 1 to 8, running out to a depth of 32 ft. at extreme low water; character of bottom, 2 ft. of mud over sand and indurated gravel, into which wooden piles can be driven by impact less than 8 ft.; the water alongside the wharf to be at least 25 ft. deep at mean low water, and 30 ft. at mean low water 15 ft. from the face of the wall; coping of the wall to be 5 ft. above mean high water.

The wall is to be of a permanent character, located in a semi-tropical climate, where the teredo is very active. The design is to include bollards.

Water Supply.

A town of 40 solidly built blocks, each block being 200 ft. wide and 400 ft. long and containing 32 4-story dwellings, is to be fur-

nished with water from four non-flowing bored wells located outside of and one-quarter mile from one end of the town.

The town is located in a flat country, and is laid out in a rectangle four blocks wide and ten blocks long, with streets 60 ft. wide.

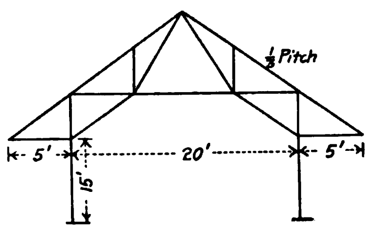
Design and lay out a complete water system from the wells to fire-plugs and house connections.

Sewer System.

A tidal river flows beside one of the long sides of a town. The surface of the land is 2 ft. above extreme high water and 5 ft. above mean low water, the mean range of tide being 18 in. Design a separate system of sewers for the above-described town and include house connections.

Strains in Structures.

The accompanying sketch shows the outline of columns and roof trusses of a steel-frame mill building 47 ft. long, to be erected in Washington, D. C. It is to have double doors in the ends, single doors and box-frame windows in the sides; its roof and sides to be covered with No. 22 corrugated galvanized steel. The columns are to be bolted down to concrete pedestals in the ordinary way, and are continuous from ground to top chord of trusses.



Determine the frame for a proper dead load and snow load combined, and for a wind load of 30 lb. per sq. ft. against a vertical plane, paying special attention to knee braces and columns. Show the purlins, side framing, etc., and show main details. Solve graphically and find stresses at one section analytically.

Crane.

An electric traveling crane is to be installed in a new shop (not yet built), of which the span between outside flanges of columns is 50 ft. The capacity of the crane is to be 30 tons. Sketch out the arrangement of the crane as regards general details as to its con-

struction and the design of the building as affected by the installation of the crane.

Briefly outline the calculations necessary to the design of the crane girders, defining the position of the load for the various maximum stresses.

Chimney.

Using free-hand sketches, design a round brick chimney for a plant of 1 200 HP. on a good clay stratum.

Determine the center of pressure and direction of the resultant of forces, using a horizontal wind-pressure of 30 lb. per sq. ft. and the usual weight per cubic foot for brick masonry.

Electric Machinery.

1. Give a diagram of a six-pole compound-wound, direct-current electric generator.

2. Give switchboard instruments and connections for two generators and six feeder circuits.

3. Describe the wiring of a three-wire system to use 110-volt lamps and 220-volt motors.

4. Describe open and enclosed arc lamps; state which is more economical and give the reasons.

5. In ordinary machine-shop practice, where there are traveling cranes, would you use direct-current or alternating-current machines? Why? What are the principal conditions for best use of alternating-current power plants?

EXAMINATION QUESTIONS FOR CANDIDATES FOR THE POSITION OF CIVIL ENGINEER, U. S. NAVY.*

The grade of Civil Engineer in the United States Navy is now full, and vacancies which may occur in the future will be filled by promotion from the grade of Assistant Civil Engineer. At present there are no vacancies in the grade of Assistant Civil Engineer. The last Congress, however, passed a law authorizing the appointment of three Assistant Civil Engineers each year until the full number of twelve is reached. Under the provision of this law, there will be three vacancies in the grade on Jan. 1, 1904. An examination will probably take place next November or December, for the purpose of receiving eligibles for appointment immediately after Jan. 1, 1904. A vacancy in the corps will occur as the result of retirement in March, 1904, and should a sufficient number of candidates pass the examination in November or December, it is probable that this vacancy will be filled by appointment from that list of eligibles. As it is likely that some of our readers may wish to take this examination, we have secured from Admiral Mordecai T. Endicott, Chief of Bureau of Yards and Docks, Navy Department, and publish herewith the questions submitted to candidates at the last examination. These same questions will not, of course, be asked in the coming examination, but they may prove helpful to prospective candidates as a general index of the character of the examination to which they will be subjected.

To repeat information which we have already given, Assistant Civil Engineers will enter the corps with the pay of $1 800 per annum, which at the end of five years will be increased to $2 100. Assistant Civil Engineers, as well as Civil Engineers, are regularly commissioned officers in the U. S. Navy, subject to all the provisions of law relating to such officers, namely: retirement on three-quarters pay upon arriving at the age of 62, or if disabled in the line of duty; pension to family in the case of death in the line of duty, etc. It may also be noted that candidates who think of taking the coming examination should have the question of their health and physical soundness definitely determined by a reputable physician before subjecting themselves to the time and expense incident to appearance before the examining board. The medical examination required by the orders of the department is rigorous, and in the last examination numbers of young men were disqualified by the Medical Board. The questions asked at the last examination were as follows:

English Grammar and Composition.

1. The papers of the candidates will be marked for this question.

2. State in not less than 500 words whether in your opinion it

* From *Engineering News*, August 13, 1903.

should or should not be the policy of the United States to increase the number of its foreign naval stations and why.

3. Correct, in the body of the sentence the following, where necessary.

(*a*) Though John, George and myself were there, the sentiment of the meeting were so strongly in opposition against our ideas that we could do nothing for our cause.

(*b*) The formula for these circulations are so intricate as to render the results extremely liable to inaccuracies.

(*c*) The indices of these books are objected to on the ground that their inaccuracy and incompleteness renders them almost wholly useless.

(*d*) Even when given work that they should be used to, neither the blacksmith or his helper were able to show their ability.

(*e*) They, who so often rail at fortune, are the very ones, who, given the opportunity, never betters their condition.

(*f*) It has occurred to Henry and myself that, though the data is not complete, we could get the result by interpolation.

(*g*) It is they who make the most mistakes who consider themselves nearest perfection.

(*h*) I wish I was able to go but I will not have the time to.

(*i*) Should either John or I be invited we will have to go.

(*j*) Gents will be allowed to smoke on the four rear seats only.

4. Define the following: Metonymy, allegory, metaphor, dactyl, tautology. Illustrate by examples.

5. Give the present indicative, present infinitive, past indicative and perfect participle of the following: Were, lost, loosen, bat, bit, bid, crow, went, lean, slink.

Arithmetic.

1. It is desired to use the same panel length in the construction of three buildings whose dimensions are to be as follows: 283 ft. 9 in. by 50 ft., 132 ft. 5 in. by 50 ft., and 189 ft. 2 in. by 50 ft. What is the greatest length that can be adopted?

2. If eight excavators dig a ditch 4 ft. wide, 10 ft. deep and 200 yds. long in 50 days of 10 hours each, how many nights of 7 hours each will four excavators require to dig a ditch 3 ft. wide, 8 ft. deep and 500 ft. long, assuming the difficulty of working at night to be one-seventh greater than by day and the hardness of the ground in the smaller ditch to that in the larger ditch as 6 is to 5?

3. The market quotation for Hemlock, Yellow Pine, White Pine, and Oak are \$20, \$30, \$72 and \$80 per M., respectively. The total cost of a certain job is \$7 200, of which 60% is for lumber. Of the total cost of the lumber, 18% is oak, 12 by 14 in.; 28% is white pine,

1 by 4 in.; 34% is yellow pine, 6 by 10 in., and the remainder hemlock, $2\frac{1}{2}$ by 8 in. Find the number of lineal feet of each.

4. Find the sixth root of 2749.865307480007 to three decimal places.

5. A contractor buys cement at 43 cts. per bag, sand at 52 cts. per cu. yd., and broken stone at $1.10 per cu. yd. If the bulk of 7 bags of cement is 8 cu. ft. and the voids in the sand and stone are 35% and 42% of their respective bulks, find the value of the material used in making 67 cu. yds. of concrete of $1:2\frac{1}{2}:5$ mixture, allowing 5% for waste.

GEOMETRY.

1. What is the measure of the angles formed by two chords intersecting within the circumference of a circle? Prove the proposition.

2. What is the area in square feet of a quadrilateral circumscribed about a circle whose radius is 48 ft., if the perimeter of the quadrilateral is 400 ft.?

3. The volume of a certain cone of revolution is 1 200 cu. in. and its altitude is $26\frac{2}{3}$ in. What is the volume of the rectangular prism whose base is circumscribed about the base of the cone and whose altitude is that of the cone?

4. A regular hexagonal pyramid is circumscribed about a circular base, the perimeter of the circle being 117.8 in. If the slant height of the pyramid is equal to the diameter of the circle, what is the lateral area of the pyramid?

5. The apothem of a regular pentagon is 34.6 and a side is 50; find the perimeter and area of a regular pentagon, the apothem of which is 8.

ALGEBRA.

1. Multiply $a^{\frac{3}{2}} b^{-\frac{1}{2}} + 2a^{\frac{1}{3}} - 3b^{\frac{1}{2}}$ by $2b^{-\frac{1}{2}} - 4a^{-\frac{1}{3}} - 6a^{-\frac{2}{3}} b^{\frac{1}{2}}$

2. Solve $\sqrt{3x+1} = \sqrt{9x+4} - \sqrt{2x-1}$.

3. Expand $\sqrt[3]{1-2x-2x^2}$.

4. A and B run a mile race. In the first heat A gives B a start of 11 yards and beats him by 57 seconds; in the second heat A gives B a start of 81 seconds and is beaten by 88 yards. In what time can each run a mile?

5. A gives to B and C as much as each of them has; B gives to A and C as much as each of them has; and C gives to A and B as much as each of them has; in the end each of them has $6. How much had each at first?

TRIGONOMETRY.

1. Prove that $\sin 3x = 3 \sin x - 4 \sin^3 x$.

2. Derive the trigonometrical functions of 30°. Give the values of the functions of 0°, 90°, 180°, 270°.

3. Prove that $\tan x + \cot x = \frac{2}{\sin 2x}$.

4. In any oblique triangle state and prove the relation of the sides and a function of the angles opposite and show how this is used to derive a formula for the solution of triangles in which a side and the adjacent angles are given.

5. Given two sides and the included angle, derive a formula for use in obtaining the area of any oblique triangle. The angles being A, B, C, and the sides opposite a, b, c, find the area when $b = 20.25$, $c = 30.27$ and $A = 30°$.

ANALYTICAL GEOMETRY.

1. Given the general equation of the line

$$Ax + By + C = 0$$

what are the values of the following:

(a) The intercept on the axis of x.

(b) The intercept on the axis of y.

(c) The normal distance of the line from the origin.

(d) The tangent of the angle the line makes with the axis of x.

(e) If A, B, and C are all positive, in which quadrant does the normal lie?

(f) What relation must exist between the constants for the normal to lie in the first quadrant?

(g) If B and C are positive and A negative, in what quadrant does the normal lie?

2. Find the equation of the circle whose center is at the origin of co-ordinates, and which is tangent to the line $3y - 9x = 11$.

3. What is the equation of the chord of the circle $x^2 + y^2 = 136$ which passes through $-2, -7$, and is bisected at this point?

4. For what point of the parabola $y^2 = 18x$ is the ordinate equal to three times the abscissa?

5. Find the length of the line

$$\sqrt{3}\, y + x - 14 \sqrt{3} = 0$$

intercepted by the co-ordinate axes. What angle does the line make with the axis of X?

Calculus.

1. Find the first derivative of y with respect to x of

$$(a)\ y = \log (3x^2 + x)$$
$$(b)\ y = x^n a^x$$
$$(c)\ y = \sin^3 x \cos x$$
$$(d)\ y = \frac{\tan x - \tan^3 x}{\sec^4 x}$$
$$(e)\ y = \tan - \frac{x + a}{1 - a x}.$$

2. Find a quantity x, such that it shall exceed its cube by the greatest possible value.

3. Integrate:

$$\int_0^a \int_x^{2x} \int_0^{xy} x^3 yz \, dx \, dy \, z.$$

4. A rectangular box, open at the top, with a square base, is to be constructed to contain 300 cu. in., what must be its dimensions to require the least material?

5. Find the area included between the curve $a^2y = x^3 + ax^2$ and the axis of x, between the limits $x = - a$, and the origin.

Surveying and Instruments.

1. Describe in detail the work of measuring an accurate base line for a topographical survey covering 500 square miles. What instruments are required?

2. State how you would organize, and the instruments with which you would equip, a party for running a preliminary survey for the location of a railroad line. Describe in detail the process of making the survey, and the operations involved.

3. Describe three methods of making a contour survey and explain when each would be used.

4. Name in proper order the principal adjustments of the transit and describe how they are made.

5. Sketch a longitudinal section through a Y-level, showing the principal parts, including the position and shape of the lenses.

6. Give field adjustments for a Y-level. How would you use a level which is out of adjustment to get accurate elevations?

7. A tidal river, main channel 400 ft. wide, is to be dredged to a depth of 32 ft. at mean low water. It is proposed to pay for the work on the basis of place measurement. The exact location of the plane of mean low water is not yet known. A low sandy beach is parallel to channel. Describe how you would make all the necessary observations, and how you would make hydrographic survey where soundings and estimates must be made quickly and often. State method of making soundings, equipment needed, precautions necessary to secure accurate work, and number and position of men required. State what method you would use to determine whether any small, isolated rocks remain in channel on completion of work.

8. On the sketch below (Fig. 1), the heavy line indicates the axial location of a ship canal which is to be 300 ft. wide on the bottom, side slopes 3 to 1, depth of water 30 ft., 20-ft. berms on each side 6 ft. above the water. Plot on the sketch the plan of the completed cut, give a cross-section at A, B and C and figure the volume of excavation between A and C.

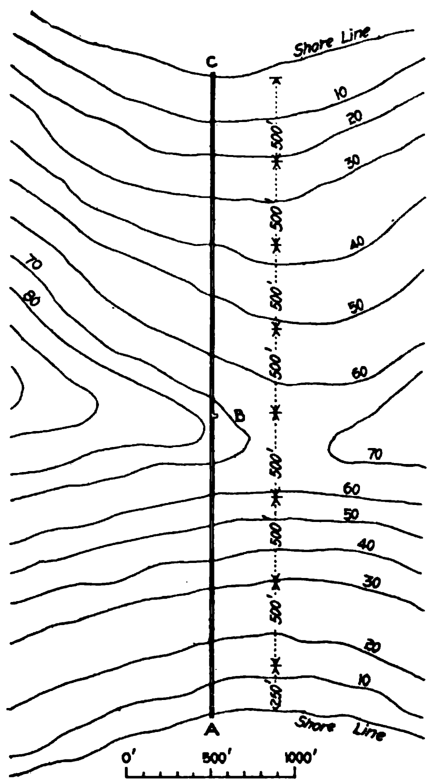


FIG. 1.

9. (*a*) It is decided to establish a naval station in Great Harbor, Culebra (see chart).

Indicate thus *A* on the chart, the location of primary triangulation stations for a survey of the harbor and adjacent region and connect them. Locate a suitable base and connect with the triangulation.

(*b*) State how you would obtain complete tidal data concerning the port.

(*c*) Make perspective sketch of harbor entrance and south shore of island from point marked *A*.

(*d*) Make a paper location of a railroad from San Ildefonso to Ensenada Fulladora.

(*e*) Plot the dangers to navigation given on the following sheet.

[(281) WEST INDIES—CULEBRA ISLAND—GREAT HARBOR—ROCK REPORTED.—Lieutenant C. M. Fahs, U. S. Navy, navigator of the U. S. S. "Olympia," reports the existence of a rock, with 18 ft. of water over it, outside of the Great Harbor, Culebra Island, which was discovered while surveying. The rock is located 1 270 yd. S. 12° 45′ W. true (S. by W. ¼ W. Mag.) from the house on the south beach of Punta Carenero, shown on U. S. Coast Survey chart No. 913.

(2025) PORTO RICO—CULEBRA ISLAND—GREAT HARBOR APPROACH—GROUPER SHOAL—ROCK TO WESTWARD.—Information has been received from Lieutenant C. M. Fahs, of the U. S. S. "Olympia," that while surveying he found a coral head or rock, some 6 ft. sq., with only 13 ft. of water over it. Its position as taken from the small house on the south beach of Punta Carenero, is S. 3° W. true (S. ⅜ W. Mag.), distance 1 060 m. (1 159 yd.).

The rock lies right in the western channel leading along the reef toward Great Harbor. A buoy, No. 2½, has been placed about 10 ft. to the westward of the rock in 7½ fathoms of water to mark its position.]

PHYSICS.

1. Show by diagram the principle of the ordinary sextant.

2. Show how the position of metacenter affects the stability of a floating body.

3. What weight placed 2 ft. from the axis of a wheel will balance a weight of 18 lb. placed 4 in. from the axis, while the wheel is revolving?

4. Give three methods for the transmission of heat and illustrate by examples.

5. Define specific gravity. Describe method of obtaining the specific gravity of Portland cement, and state what specific gravity you would expect to obtain.

6. Explain the principle of the screw jack and illustrate by diagram the actual power required at the end of a 30-in. lever, to lift a weight of 10 tons, the pitch of the screw being five turns per inch. The diameter of the screw is $3\frac{1}{2}$ in.

7. In what proportion must water at a temperature of 30° and linseed oil (specific heat 0.5) at a temperature of 50° be mixed so that there are 20 kilograms of the mixture at 40°?

8. What is the relation between the graduations on the three standard thermometers?

9. The diameter of a steam engine cylinder is 9 in.; the length of crank, 9 in.; the number of revolutions per minute, 110; the mean effective pressure of the steam, 35 lb. per sq. in. Find the indicated horse-power.

10. Two bodies are let fall from the same point at an interval of two seconds. Find the distance between them after the first has fallen for six seconds.

Geology.

1. Name the principal rocks, describe their formation and composition. What is the primary division of rocks?

2. What are anticlines; synclines; faults? What are the dip and strike of strata? What are unconformable strata? What is meant by metamorphic rocks and what are the principal ones? What their composition? What is the most common sedimentary rock and what is its composition?

3. What is a glacier? Describe general characteristics and name three well-known ones.

4. What is an iceberg and how formed? Upon what does the erosive power of a stream depend? Explain what ratio governs its transporting power.

5. Outline in briefest form present theories as to seismic and volcanic action.

Engineering Construction.

1. Make a detail drawing of the roof truss and columns shown in Fig. 2.

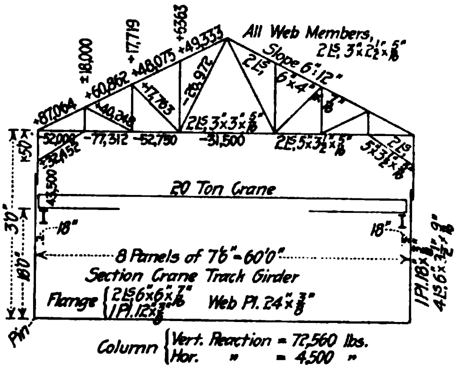


FIG. 2.

Allow 10 000 lb. per sq. in. shearing value on rivets.
" 20 000 " " " " bearing value on rivets.
" 250 " " " " pressure on bed plates.

The maximum size of members which can be shipped is 11 ft. wide by 35 ft. long. Purlins to be 10 in., 15-lb. channels at each panel point.

2. Make sketches showing construction of a concrete-steel floor and describe briefly the materials and construction.

(1.) For a warehouse, floor beams to be 6 ft. on centers, load 500 lb. per sq. ft.

(2.) For an office, floor beams as in (1), load 100 lb. per sq. ft., to have a wooden wearing surface and suspended ceiling beneath.

(3.) For a toilet room, floor resting directly on the ground.

Make sketches of a terra-cotta floor end construction.

3. Make sections showing the construction of a double-hung window in an office building with brick walls. Name all parts. Show construction of a 4-in. terra-cotta partition plastered both sides. Of a 2-in. solid-plaster partition and door frame. What is the maximum height for which the above partitions should be used?

Masonry and Foundations.

1. Give the different kinds and qualities of brick used for ordinary building construction. State for what class of structures each is used and the method of laying each to secure the best results.

What precautions should be observed in laying brickwork in this vicinity as regards conditions of weather? When may lime mortar be used and when never used?

2. Give the usual methods employed to determine the bearing power of soils, making detailed sketches where necessary.

3. Using an ordinary drop hammer weighing 3 000 lb., the leads being 60 ft. in length, state what formula you would use to determine the bearing power of piles, discuss the formula, and discuss also the process of driving piles, stating which methods to employ and which to avoid in order to secure the best results, paying special attention to height of fall.

4. A column of a certain tall building supports 360 tons total load. The material of the building site will support $1\frac{1}{2}$ tons per sq. ft. safely, and piles cannot be used. Design a foundation in steel and concrete, with pedestal, for Z-bar column of 4 Zs 6 by $\frac{3}{4}$, 1 pl. 8 by $\frac{3}{4}$, and 2 pls. 14 by $\frac{3}{4}$. The foundation is limited in length to 20 ft.

I = 795 for 18-in. I-beam.
I = 609 " 15 " "
I = 268 " 12 " "
I = 122 " 10 " "
I = 57 " 8 " "

5. A masonry pier supporting a highway bridge is to be located in a stream at a point where the depth of water is 11 ft. at normal stage. The bottom is mud with hard clay at a depth of 40 ft. The roadway is 35 ft. above normal stage of water and the greatest recorded flood stage is 15 ft. Make sketch showing pier and foundation, also sketches of such auxiliary construction as may be employed. Dimensions required.

MECHANICS.

1. A column supports two crane girders 20 ft. and 24 ft. long respectively (Fig. 3). The rolling loads on these girders are as follows and always have the same relative order with respect to the spans. Find the maximum load on the column and the maximum shear at the end and centre of the 24-ft. span.

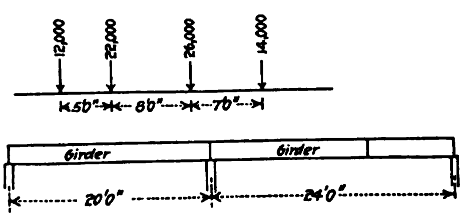


FIG. 3.

2. A beam inclined to the horizontal at an angle of 30° and carrying a uniform load of two tons per horizontal foot rests against a vertical wall at its upper end and is anchored to a pier at its lower end; the distance from face of wall to center of pier is 25 ft. If the pier is 10 ft. high and of square section, what must be its size to insure stability, the weight of masonry being 150 lb. per cu. ft.?

3. A certain arch is 2 ft. 6 in. deep at the keystone and has a rise of 5 ft. and a clear span of 60 ft. If the total uniform load, including the dead weight, is 2 000 lb. per sq. ft., find the pressure per square inch at the center, the reactions at the abutments and show the method of obtaining the line of pressures.

4. A column 32 ft. high is securely anchored at the base and loaded with 150 000 lb. on top and 60 000 lb. 24 ft. above the base and 18 in. from the center line of the column in the plane of the web. If the column is an I-section, composed of a web plate 16 by ½ in., and four angles 6 by 3½ by ½ in., with the 6-in. leg at right angles to the web, what is the maximum fiber stress in the column?

5. The top-chord panel of a roof truss, composed of two 6 by 3½ by ½-in. angles of 5-ft. clear span, has a direct compressive stress of 98 000 lb. and supports a uniform beam load of 600 lb. per ft. of span. What is the combined stress per square inch? The I of the section is 33.2.

6. A cone of revolution whose base is 10 in. diameter and altitude 15 in. is immersed, vertex down and base parallel to the surface of water. The base is 10 ft. below the surface. Find the pressure on the conical surface and the tendency of the body to rise to the surface.

7. A concrete well is built in a reservoir. The height of the wall is 35 ft., the elevation of the outside water 30 ft., and the interior is pumped out to a depth of 8 ft. from the bottom. If the wall is 18 in. thick, what is the pressure per square inch in the body of the wall at a depth of 30 ft. from its top? Diameter of well = 40 ft.

8. The weight of bituminous coal being 50 lb. per cu. ft. and its angle of repose 45°, design a wall to retain coal 18 ft. high, flush with its top. What modification must be made if the coal is piled at its natural slope, its toe being at the top of the wall?

9. Define the following:

Moment of inertia,
Center of percussion,
Radius of gyration,
Elastic limit,
Modulus of elasticity,
Resilience,
Factor of safety.

10. What weight "W" is necessary to balance the load of 5 000 lb. (Fig. 4)?

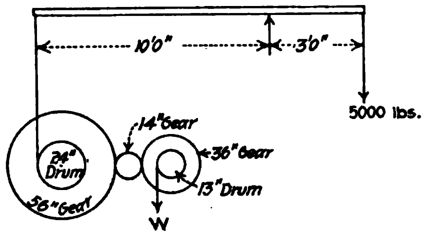


FIG. 4.

STRESSES IN STRUCTURES.

1. A train-shed roof is supported by trusses spaced 20 ft. on centers on an outline shown on accompanying sheet. The total load on the roof is 60 lb. per sq. ft. Find the stresses in the truss graphically and proportion the members. What unit stresses would you allow? Make a sketch showing arrangement and size of lateral bracing you would use for first four panels from outer end of shed. Show stresses on left half and sizes on right half of diagram (Fig. 5).

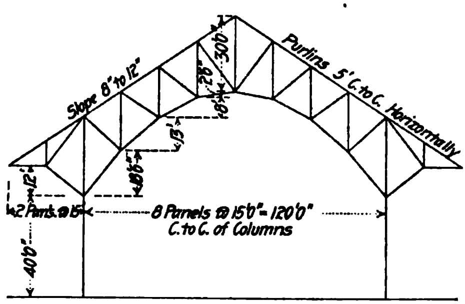


FIG. 5.

2. Find stresses in frame (Fig. 6) analytically.

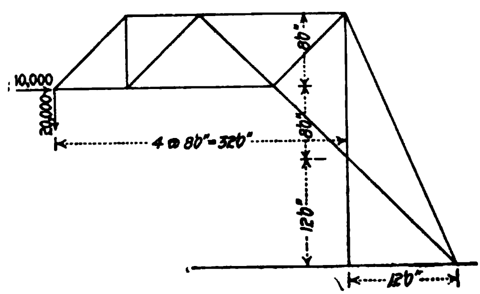


FIG. 6.

3. Determine stresses in frame shown above (Fig. 7) for loading given. The column is a stiff member from the pin at the ground level to the bottom chord of the roof truss.

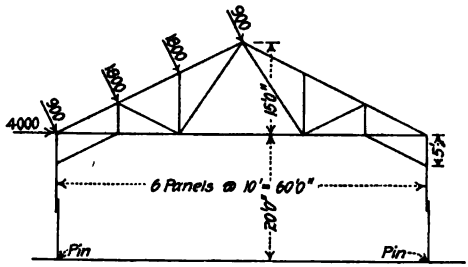


FIG. 7.

PAVEMENTS.

1. Specify all the materials and the finish of a granolithic sidewalk.

2. Sketch cross-section and describe materials and construction of a street 91 ft. between lines, laid out as follows: Double-track street railway in centre, 4 ft. 8 in. gage, 10 ft. 4 in. centers, paved with granite blocks; on each side of a track a roadway 18 ft. wide, paved with asphalt; gutters, 2 ft. wide each, of vitrified brick; granite curbs; cement sidewalks, 8 ft. wide; parking, 10 ft. wide. Indicate on the sketch the various sub-constructions in the street and their connections.

3. What crown would you give to street paving? What minimum grade of gutters? What do you consider to be the limiting grades for asphalt paving, vitrified brick, granite block, macadam? Why?

MATERIALS OF CONSTRUCTION.

1. Write a specification for good building sand and for gravel for foundation concrete. What should be the size of sand particles to make the strongest mortar?

2. Write a specification for paving brick; describe tests that should be made on same.

3. Why is open-hearth steel preferred to Bessemer for structural material? With open-hearth steel, would you prefer basic or acid for structural material? Why?

4. What is Rosendale cement? Describe its manufacture. What do you understand by Portland cement? Describe its manufacture.

5. Write a specification for lime to be used in the construction of a brick building. Specify the mixing of mortar for the above.

6. What is the composition of commercial roofing plates of so-called tin? How are they made? How is the thickness of copper for roofing purposes specified? What are its advantages over tin or galvanized iron?

7. Discuss rusting of steel and methods of preventing by painting. What paint would you use on sheet-steel roofs? On corrugated steel sides? On steel framework of buildings? Why?

8. What kind, grade, and quality of wood would you specify for a timber wharf, above the tops of the piles? For a railroad trestle? For railroad ties? For the floor of a shop? For the floor of an office? For a shingle roof? For the frames and siding of a wooden building? For the doors and windows of a dwelling?

9. A circular pump well 30 ft. in diameter, with concrete bottom and sidewalls about 4 ft. thick, is to be made waterproof against a maximum head of water of 30 ft. Design and specify material and workmanship for waterproofing.

10. Name the various kinds of glass manufactured and state the purposes for which generally used.

Water-Works.

1. A 12-in. pipe on a grade of 3 ft. per thousand is flowing half full. Assume a coefficient of friction, and find the discharge of the pipe per second.

2. Write an outline specification for the laying of 16-in. cast-iron water main in this vicinity to carry a working pressure of 125 lb. Describe briefly the most important features to be looked after to secure the best results. Part of the main is laid in rock and part in very soft, wet ground. The thickness of the above pipe is $\frac{3}{4}$ in. What is the stress per square inch in the metal?

3. A town of 40 000 inhabitants is to be supplied with water for domestic consumption at an average rate of 60 gal. per capita per diem. The water is furnished from a reservoir through a cast-iron pipe line 2 miles long to a center of distribution in the town. Give the size of pipe necessary. The water level in reservoir is 200 ft. above center of distribution and located on comparatively level ground. Sketch a section and give area of a square reservoir with concrete core wall and earth embankments to contain a 30 days' supply. Location of reservoir is in good sand and clay, mixed.

Railways.

1. What are the relations between frog number, throw, lead, gage, radius of curvature, etc., of a turn-out? Describe each, and give formula. What is the minimum radius of curvature you would use for Navy Yard work where standard-gage cars are to be shifted?

2. Sketch a section through a steam railroad track suitable for permanent construction in a street paved with vitrified brick or granite blocks.

3. Make a sketch plan of a set of crossing-frogs for standard-gage steam railroad tracks, the angle of the crossing being 60° and the traffic over the crossing being heavy and at considerable speed.

4. Make a sketch of a spring-rail frog, and of a solid-filled, bolted frog.

Sewers.

1. Design the sewers as shown on the accompanying sketch (Fig. 8), figuring the sizes, locating man-holes, catch-basins, etc. The river bank is at M. H. W. and the point *A* at 15 ft. above M. H. W. with uniform grade toward river. The sewer is of the separate type and the water consumption is to be figured at 100 gal. per capita, with 300 residents on each block. No provision for growth of city.

2. What data are required for the design of a combined system of sewers and how would you proceed to calculate the conduits?

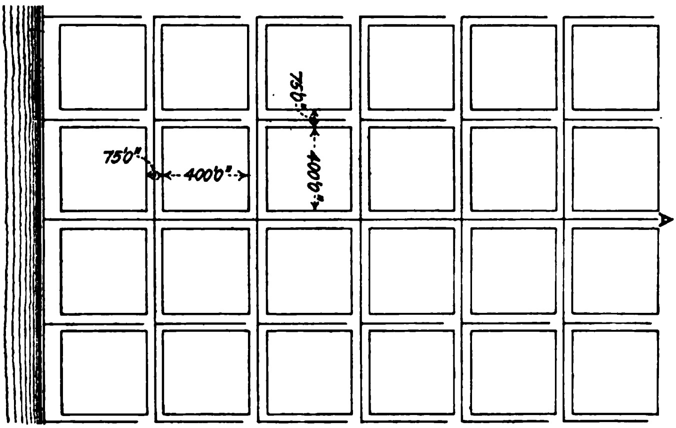


Fig. 8.

Wharf.

1. A timber pier 300 ft. long and 60 ft. wide is to be built projecting into a tidal river with mud bottom, varying from mean low water at the shore to a depth of 18 ft. at M. L. W. at the outer end. After the construction is completed berths are to be dredged on both sides to a depth of 25 ft. at M. L. W. The height of the deck above M. L. W. is 14 ft. The test piles driven to determine the bearing power of the bottom showed a total penetration below M. L. W. of about 36 ft., bringing up with a penetration of 1 in. per blow of a 2 800-lb. ram falling 20 ft. Design the wharf, showing neat free-hand sketches of the principal details. Make a complete bill of material and estimate the cost of all items to be purchased.

Boilers.

1. Design a battery of boilers of the return fire tubular type, to supply 500 HP. at a steam pressure of 100 lb. per sq. in. The grate-surface, area over the bridge-wall, flue area, and general dimensions cf chimney, all to be fully shown.

2. What is the rate of coal consumption per horse-power for the boilers of problem 1? How much water is evaporated per pound of coal? What is the ratio of heating-surface to grate-surface? How much heating surface is required per horse-power?

3. Give full details of a complete boiler test to determine efficiency.

4. Describe briefly the several types of condensers in use.

GENERAL APPENDIX II.

CIVIL SERVICE OF THE STATE OF NEW YORK.

GENERAL INFORMATION.*

PERSONS WHO WILL NOT BE EXAMINED.

No person is eligible to a competitive examination—(*a*) who is not a resident and citizen of New York State (except as indicated below), (*b*) who is not within the age limitations prescribed for the examination for which he applies, (*c*) who is physically disqualified for the service which he seeks, (*d*) who is addicted to the habitual use of intoxicating beverages to excess, (*e*) who has been dismissed from the public service for delinquency or misconduct within one year preceding the date of his application, (*f*) who has failed, after probation, to receive absolute appointment to the position for which he again applies, within one year from the date of the expiration of his probationary service, (*g*) who, within nine months has taken the same kind of examination for which he wishes again to apply, (*h*) who has made a false statement in his application or has been guilty of fraud or deceit in any manner connected with any application or examination under the Commission, or who has been guilty of crime or infamous or notoriously disgraceful conduct.

Non-residents or non-citizens may be admitted to examination for the following positions: Attendants, nurses and orderlies in asylums and hospitals and similar institutions; also for positions as scientists, technical and trade instructors and positions requiring special training and education, provided that if the eligible list resulting from any examination held for such a position contains the names of three or more persons who are citizens and residents of New York State, such persons shall be preferred in certification to non-residents.

PRELIMINARY REQUIREMENTS AS TO EDUCATION, EXPERIENCE, ETC.

No application for examination will be accepted unless the applicant satisfies all the preliminary requirements as indicated in the description of the particular examination. For professional positions candidates will be required to have the licenses required by law for practice of their respective professions in the State of New York. For positions in the Regents' office candidates must be graduates of a recognized high school or have an equivalent education,

* Extracts from Manual of Examinations of the New York State Civil Service Commission.

according to the standard of the Regents. For positions involving a knowledge of any trade candidates will be required to present evidence of having served the customary apprenticeship at such trade.

Where Examinations May Be Taken.

The Commission is required by law to hold examinations for all positions, except those the examinations for which "require special tools, machinery, appliances or laboratory facilities," in the following cities and towns:

Albany	Hornellsville	Newburg	Rochester
Amsterdam	Ithaca	New York	Syracuse
Auburn	Jamestown	Ogdensburg	Utica
Binghamton	Kingston	Olean	Watertown.
Buffalo	Lockport	Plattsburg	
Elmira	Malone	Poughkeepsie	

What Applicants Should Bring to Examination Room.

Persons taking the stenographer and typewriter examinations must provide themselves with typewriting machines and stands or tables; those taking the bookkeeper, draftsman, or other examinations requiring the use of instruments, must furnish the instruments required. Candidates for draftsman or tracer must bring drafting-boards suitable for paper 8½ by 14 in. All competitors must provide themselves with pens, penholders, pencils, erasers, ink and blotters. Competitors should not bring any paper for use in the examination room, as sufficient blank paper will be furnished for all purposes.

Each applicant *must present* his notice of examination in order to be admitted to the examination.

Change of Address.

Applicants and eligibles must keep the Commission informed of any change of post-office address. A failure to do so will be treated as the fault of the applicant or eligible, and may result in his losing an opportunity of examination or appointment. Requests to have the address changed should be made by letter, and should state whether the applicant has been examined or not. Such letter should relate only to the change in address.

Rules Governing Competitors in Examinations.

The following is a copy of the rules which are given to each competitor at the beginning of every examination:

1. You will find your examination number in the upper right hand corner of the declaration sheet which will be given you. *Write*

that number on each sheet of the examination. Fill out all blanks on question sheet before handing it in.

2. See that each sheet received by you pertains to the kind of examination which you are taking, and take care that you do not omit any of the sheets. Competitors are held responsible for errors and omissions.

3. Do not leave the room, if possible to avoid it, with a sheet before you unfinished, for if you do, the sheet will be taken up and will not be returned to you. Competitors are allowed to leave the examination room for luncheon on the completion of any sheet of questions after 12 o'clock. *No additional allowance of time* will be granted on account of such absence.

4. *Read carefully the printed instructions on each sheet before commencing work thereon.*

5. A question sheet spoiled by you cannot be exchanged for another of the same kind.

6. Perform all work on each examination sheet with ink.

7. Pencil and scratch paper furnished by the examiner may be used in preliminary work, except in spelling and verbal order exercises, which must be written with ink directly on the examination sheets from the dictation of the examiner.

8. Use no scratch paper except that furnished by the examiner, and, on completing an examination sheet, hand him the scratch paper pertaining to that sheet. Have all your work complete on the examination sheet however, as the scratch paper is collected, not for consideration in the marking, but for destruction.

9. No helps of any kind are allowed unless expressly stated to the contrary on the question sheet or in the instructions sent to candidates. Before the examination is commenced, hand to the examiner any written or printed matter that you may have which might, if used, aid you in your work.

10. *All conversation or communication between competitors during the examination is strictly prohibited.*

11. Do not copy or attempt to copy from the work of any competitor, or permit any competitor to copy from your work, or to read the examination sheets in your possession.

12. All necessary explanations will be made to the whole class. Examiners are forbidden to explain the meaning of any question

or to make any remarks or suggestions that may assist in its solution.

13. From one to three months may elapse before you are notified of your standing. No unnecessary delay will occur in marking your papers, and you are requested not to increase the labors of the Commission by making inquiries in regard to your standing, unless you have reason to believe that the notice to you has miscarried.

14. Copies of examination papers or examination questions must be handed in with the answers and *must not be taken from the room.*

[N. B.—A violation by you of the instructions contained in paragraphs 9, 10 and 11 will be deemed sufficient cause for canceling your papers. You are requested to report to the examiner any irregularity that may come under your notice during the examination.]

Method of Marking Examination Papers.

The following method is observed in marking examination papers by the examining division of the Commission:

After an examination is held, the papers are arranged by sheets or subjects and are forwarded under seal to the Commission. When they are reached in the order of marking, they are distributed by sheets to the examiners, Examiner A being given all of sheets 1, Examiner B all of sheets 2, Examiner C all of sheets 3, and so on. The work of each examiner is usually reviewed by another. When all of the papers of an examination have been marked, those of each competitor are then for the first time assembled or brought together, his general average is ascertained, his declaration envelope is opened, and the declaration sheet to which he has signed his name is attached to his examination papers. The identity of the competitor, therefore, is not disclosed *until his papers have been marked and reviewed and his general average determined.* The only exception is in marking experience and education, which is done upon the candidate's sworn statement and the answers received to letters of inquiry sent by the Commission to former employers and others acquainted with the competitor. As the charges for specific errors are fixed by the rules for marking, it will be seen that absolute impartiality, accuracy and uniformity are secured in the work.

Appeals from the markings are sometimes made by competitors, but the prospect of securing a higher average by such action is small. Errors on the part of examiners in making charges are seldom found.

The papers of all the competitors in an examination must be marked at the same time, and no competitor's papers will be made special or be marked in advance of others.

Rules for Marking Examination Papers.

In subjects for which specific rules of marking are not prescribed, the examiner will usually prepare a scheme of marking for each question, so as to be able to explain his marks in case they are questioned.

All examination papers shall be marked under the following rules:

Mark every correct answer.................................. 100

Mark every faulty answer according to its value on a scale of 100, or as specifically directed below, deduct the sum of the error marks of such answer from 100.

When the question requires in the answer a specified number of states, countries, persons, places, locations, or things, the quotient arising from the division of 100 by the number of states, countries, etc., required shall be the credit to be given for each state, country, etc., correctly named. If a greater number is given in the answer than is required, the additional number of states, countries, etc., shall be added to the number required by the question, and the quotient arising from the division of 100 by the number thus obtained shall be the credit to be given for each state, country, etc., correctly named.

Rules for Marking Arithmetic.

The examiner will prepare a scheme for marking each problem, giving proportional weights to the various steps or processes on the scale of 100. Charges for errors in computation in any step or process will not exceed the weight given such step or process.

No credit will be given for a wrong process.

For errors in work or operation, the following charges will be made:

	From 100 deduct—
1. For error in pointing off decimals in multiplication or division	25
2. For error in omitting decimal point or in pointing off decimals in addition or subtraction..............	10
3. For each evasion of a decimal or common fraction test in the solution of a problem.....................	25
4. For each error in computation, provided that in solutions where the possible maximum number of chargeable errors in computation is less than 10, a proportionate charge shall be made for each error..	10
5. For error in copying figures from printed question or from work, wrong result being obtained...........	10
6. For error in copying figures from printed question or from work, right result being obtained...........	5

7. For indicating wrong process, but performing correct process.	5
8. For each improper use of the symbol or designation % or ¢ in connection with a decimal expression...	10
9. For each improper or incorrect designation of a partial or final result.	5
10. For failure to indicate the answer in problems by the letters "Ans.," or otherwise, when the answer is obscured by improper arrangement.	5
11. For each failure to use the sign $ or £, or any other monetary or commercial sign, or any sign by which the relations of quantities are expressed, when the use of such is required in the statement or solution of a problem.	5
12. For each error in denominate numbers in quantity of one denomination contained in a unit of a higher denomination	15
13. For fractions in answers not reduced to lowest terms..	5 to 10
14. For an approximate result not sufficiently exact.	5 to 10
15. If, when work or operation in full is required, the correct answer is given, but no work is shown.	40
16. If, when work or operation in full is required, the process is indicated, but no work or only part of the work is shown.	5 to 40
17. For superfluous or irrelevant work not canceled.	10
18. For giving proof instead of solution, according to gravity of error.	10 to 75
19. For complex statement, process or method, right result being produced.	10
20. If, when work or operation in full is required, an approximate answer is given, but no work is shown or indicated, charge 40 for omission of work and deduct from 60 a proportionate charge for number of figures incorrect.	

Rules for Marking Experience.

In marking experience the following topics will be considered:

Age.—The examiner will determine standard limits of age most desirable for the position in question. Candidates within those limits will receive the maximum allowance for age, and other candidates will be rated according to their variation from the standard adopted.

Height and weight will be considered for positions requiring physical strength or perfection, charges being made for defect in height from the standard adopted and for any great variation in weight from the recognized standard weight for the height and age of candidate.

Education will be considered for positions reasonably requiring educational attainments above the common-school grade, and will be rated according to its value in the opinion of the examiner.

Experience.—The rating for experience will be based on kind of work done, nature and length of employment, salary or compensation, extent of supervision over others, and other facts called for in application and experience blanks.

Letters of recommendation and certificates of character will be considered *only* when received in response to the inquiry or request of the Commission. Their effect on the rating of the candidate will depend on their contents and the extent to which they corroborate the candidate's own statements.

Every fact called for in the experience statement is important to the examiner, and candidates cannot be too careful to state in detail all important facts of their history.

Failure to satisfy any preliminary requirement of age, height, weight, education, or experience established for the examination in question will disqualify the candidate, and candidates who just satisfy the preliminary requirements will usually be given a minimum standing of 75 per cent.

Prospect of Appointment.

Except as indicated in this paragraph, it is not possible to estimate the prospects of an eligible for appointment, and attempts to predict when names might be reached for certification would be certain to result in disappointment. The law requires examinations to be held, but the passing of an examination does not insure either certification or appointment. The conditions of appointment in the various branches of the service are such that nothing can help and nothing can hinder the certification of a name in the order of its standing on a register. As the highest possible mark is 100 and the lowest that gives eligibility is 75, it follows that the nearer a mark is to 100 the more likely it is that the person may be reached for certification within the period of eligibility. There are usually on the registers more eligibles having ordinary qualifications than are required for appointment.

For the information of applicants the Commission mentions the following positions as those for which it has been unable to secure sufficient qualified eligibles: Apothecary; guard, Elmira Reformatory; physician; trained nurse; woman officer, state charitable institutions; stenographer, first and second grades, in state hospitals and institutions. Persons willing to accept such positions have excellent chance of appointment if successful in passing the examination.

Entrance to the service is usually in the lowest grades, the higher grades being filled generally by promotion. The prospect of promo-

tion varies so much in the different departments that no specific information on the subject can be given.

Promotion.

Under the civil service rules, vacancies in higher grades are filled as far as practicable by promotion from lower grades. Persons desiring promotion from chainman to rodman, rodman to leveler or engineering draftsman, leveler or draftsman to assistant engineer, tracer to chainman or junior bridge draftsman, junior bridge draftsman to bridge draftsman, bridge draftsman to bridge designer, should enter the regular, open, competitive examinations for the higher positions, provided they can satisfy the preliminary requirements. If successful in such examinations they will be certified for appointment in preference to persons not in the service. Special examinations are held as required for promotion from assistant engineer to first assistant engineer ($7 a day). The position of resident engineer will be filled by promotion (upon examination) from first assistant engineer or by open competition.

ENGINEERING STAFF OF THE STATE ENGINEER.

Exempt Positions.

3 Deputies	$4 000–$5 000	per annum.
3 Division Engineers................	3 600	"

Competitive Positions.

16 Resident Engineers................	2 400	per annum.
1 Chief Bridge Designer.............	3 300	"
1 Ass't Chief Bridge Designer........	2 500	"
5 Bridge Designers..................	1 500–1 800	"
1 Mech. Engr. and Draftsman........	1 500–1 800	"
6 Bridge Draftsmen.................	1 200–1 500	"
3 Junior Bridge Draftsmen..........	900–1 200	"
5 Tracers	600– 720	"
3 First Ass't Engineers.............	7.00	per day.
85 Assistant Engineers...............	5.00– 6.00	"
34 Levelers	4.50– 5.00	"
27 Rodmen	3.50– 4.00	"
36 Chainmen	2.50– 3.00	"
25 Civil Engineering Draftsmen......	4.00– 5.00	"
6 Inspectors	4.00– 4.50	"
6 Foremen of Boring Parties.........	3.50– 4.00	"

DESCRIPTIONS AND SPECIMEN QUESTIONS OF COMPETITIVE EXAMINATIONS.

CONSULTING SANITARY ENGINEER.

STATE DEPARTMENT OF HEALTH.

$3,000.

The duties are the examination for approval of plans for water supply, sewer systems, disposal plants, etc., and other engineering work of the department. Candidates must have an experience of at least three years in sanitary engineering work, and no candidate will be accepted unless satisfactory experience of high grade is shown. Subjects of examination and relative weights: Sanitary engineering, 5; experience, 5. Time allowed, 8 hours.

EXAMINATION, MAY 12, 1906.

1 and 2. Write an essay on the most important sanitary work with which you have been connected, not less than three, nor more than five pages in length.

3. A city of 70 000 inhabitants is situated on a stream whose watershed is 200 square miles (above the city). One hundred miles distant, down stream, is another city, the water-supply of which is derived from the above stream. Discuss the methods of sewage treatment available for the city further up stream.

4. Discuss the theory and efficiency of filtration.

5. Discuss the methods by which preventable diseases are communicated and the methods used to combat them.

6. Discuss the legal aspects of the rights and responsibilities of a municipality in the use of a stream for water-supply and drainage.

7. State all the points that must be considered in the sanitary survey of a watershed.

8. Discuss the interpretation of analyses of a water-supply.

ASSISTANT ENGINEER.

$5 to $6 a day.

Candidates must have had at least three years' practical experience in civil engineering. Candidates who have graduated from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Theoretical and practical questions, including highway construction, strength of materials, canal and water-supply construction, hydraulics of canal and water-supply engineering, mechanics of engineering, specifications and estimates, topographic surveying and mapping, 10; experience and personal qualifications, 7; education, 3. Time allowed for the written examination, 8 hours. For part of the examination candidates will be permitted to use any books of reference they care to bring to the examination. The books must be left with the examiner in charge until such portion of the examination is reached.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Assistant Civil Engineer.

Held at.................... Date......................
Time commenced..........
Time finished............. Examination No..........

Directions: Time allowed for the whole examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Do not copy the question, but number the answers to correspond to the numbers of the questions. In the case of problems, all the work of solution must be given. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following:

1. Give brief specifications for concrete to be put into a concrete arch, including proper mixing (by hand) and method of putting into place. In the field, how would you distinguish Portland from Rosendale cement?

2. Describe how you would build the foundation for the above arch if (*a*) upon marshy land, (*b*) upon shale with a dip of 45 degrees.

3. What are the most important requirements for which provisions must be made in the construction of a macadam highway? Why is macadam in such general use in preference to other kinds of road?

4. (*a*) How would you ordinarily decide whether a pile is sufficiently driven? (*b*) How would you prevent a pile from splitting at either end? (*c*) Suppose a pile were being driven into a river bottom and its penetration under a certain blow of the hammer ceased, what would you conclude if, under continued driving, the penetration was gradually resumed, and what would you do?

5. Suppose the earth behind a stone retaining wall to be liable at times to become very wet; describe the methods that might be employed to reduce the danger of damage to the wall. To what damage is the wall made liable by such condition?

6. Suppose it is desired to make a survey for an accurate contour map of a tract of nearly level marsh land containing several hundred acres, in order to determine the best means of draining it. Describe in detail your method of making such survey, including organization of party, etc.

7. A 24-in. sewer pipe is to be passed through a double-track railroad embankment for the purpose of draining the land on the upper side of the track. The top of the pipe is to be 4.5 ft. below the top of the track. Explain, using pencil sketches, how you would do this without interfering with traffic.

8. A wooden beam has to support a uniformly distributed load of 200 lb. per linear foot, including its own weight, and also a load of 2 000 lb. at the center. If the span is 18 ft. and the depth of the beam is 14 in., what should be its width for an extreme fiber stress of 900 lb.?

9. A segmental stone arch has a rise of 5 ft. and span of 40 ft. What will be the approximate horizontal thrust due to a load of 40 000 lb. at the center?

10. A derrick has a mast 30 ft. high; 5 ft. from its foot is fastened the boom 20 ft. long. The length of the tie from the end of the boom to the top of the mast is 15 ft. The mast is supported by two guy ropes fastened to its top; one of them is fastened 50 ft. from the foot of the mast and its horizontal projection makes 130°

with the horizontal projection of the boom; the other is fastened 40 ft. from the foot of the mast and its horizontal projection makes 90° with that of the first guy. Find the stresses in the guys due to a live load of 5 tons on the derrick.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR ASSISTANT CIVIL ENGINEER.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. In order to find the amount of water flowing in a stream, a standard rectangular weir with sharp iron edges, having a crest 28 in. long is placed across the stream and the depth of the water is found to be 4.36 in. over the crest of the weir and the velocity of approach is found to be 0.25 ft. per second. The water from the weir is conducted down a planed board trough 36 in. wide, sloping 45° a distance of 40 ft. Find the cu. ft. of water per second flowing over this weir.

2. Find the horse-power developed at the foot of the trough in the above problem, making due allowance for the friction of the trough.

3. A canal feeder in firm gravel and earth free from weeds and rock has a bottom width of 5 ft. and sides sloping 45°; the longitudinal slope of the bottom is 1 in 1 000, and the depth of the water is 5.5 ft. Find the flow in cu. ft. per second. What depth of water will double the flow?

4. A stream having a surface width of 10 ft. flows through a small gorge in soft slate with sides arising from the banks of the stream and sloping 40° to the horizontal. The usual depth of the water is about 2 ft. Design a dam across this stream to give a center depth of 10 ft. and show that your design is stable against overturning.

5. Design the foundation for the above dam and give your calculations to determine the security of the dam against sliding or crushing of the foundation at the toe. The slate has a dip of 30° and a depth of 12 ft. overlying sandstone.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR ASSISTANT CIVIL ENGINEER AND LEVELER.

(NOTE: Sheet No. 1 same for Ass't Engineer and Leveler, second sheets different.)

DIRECTIONS: Time allowed for the whole written examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Do not copy the questions, but number the answers to correspond to the number of the questions. In the case of problems, all the work of solution must be given. Slide rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following:

1. Give in detail the best method of mixing Portland concrete "by hand." Give the reasons why Portland cement is generally preferred to natural cements.

2. Describe fully and in detail the proper method of preparing the subgrade for a macadam highway (*a*) across a level, sandy farm, (*b*) in a hilly and rocky country, (*c*) across a swampy country with a subsoil of clay.

3. What are the most important requirements for which provision must be made in the construction of a macadam highway?

4. In the construction of a macadam highway, how would you prevent (*a*) "ravelling," (*b*) sinking of the stone into the subgrade, (*c*) rapid powdering or disintegration of the stone, (*d*) a muddy or dusty road?

5. Explain in detail how you would take a series of accurate levels for determining the flow of water in a level country. How do you determine accurately the depth of the water over the crest of a weir?

6. A beam 12 ft. long is held in a horizontal position, one end resting against a vertical wall; the other end, which is to sustain a weight of 600 lb., is supported by two guy ropes fastened at the top of the wall 16 ft. above the beam, one 5 ft. to the right and the other 6 ft. to the left of the beam, which is perpendicular to the wall. Find the stress in the two guy ropes and the thrust of the beam against the wall.

7. What is the theoretical horse-power that may be supplied by a waterfall 90 ft. high and 84 ft. wide when it delivers 16 cu. ft. of water per second for every foot of its width?

8. The waste-gate in a sluiceway is 4.75 ft. wide; the water on one side is 9 ft. 6 in. deep and on the other 3 ft. 3 in. deep. Find the amount and the position of the resultant water pressure on the gate. Find the theoretical velocity with which the water will begin to flow when the gate is raised six inches.

9. What fall must be given a waterway 2 640 ft. long, 123 ft. wide at the top, 75 ft. wide at the bottom, 12 ft. deep, that it may convey 1 800 cu. ft. of water per second? (Take $c = 88$.)

10. A masonry reservoir wall weighs 120 lb. per cu. ft. and is 28 ft. high. It is 3.5 ft. thick at the top and has a front batter of 1 in 6. What should be the least back batter and thickness at the bottom in order that it may safely retain water level with the top?

11. The following is a portion of a set of field notes for a stadia survey. One full space on the rod corresponded to a distance of 100 ft. from the center of the instrument. The elevation of the instrument station was 131.57 ft. You are required to calculate the corrected distance, the difference in elevation and the elevation as called for by the columns below.

Stadia	Horizontal Angle	Vertical Angle	Corrected Distance	Dif. in Elevation	Elevation
.04	84° 37′	+8° 1′			
0.89	132 55	—1 33			
1.10	91 10	+3 12			
0.90	39 18	+4 52			
1.65	42 30	+3 22			
0.13	249 6	+3 32			
0.40	308 24	+9 35			
1.30	336 4	+4 57			
1.35	288 54	+3 23			
0.52	228 45	+3 53			

12. Plot to suitable scale the elevations you have determined in the above question and by them draw contour lines for each even foot of elevation. Do not erase the points plotted after drawing the contours. (If you are unable to calculate the elevations called for above, assume a reasonable set of elevations and plot as directed.)

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR ASSISTANT CIVIL ENGINEER.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. A stream of surface width 50 ft. and depth 4 ft. has side slopes 1¾ to 1. The sides and bottoms are of coarse gravel and pebbles with some large stone; the bed has a general fall of 0.5 per cent. Find the height of the submerged weir that will double the depth, taking into account the velocity of approach.

2. Find the pressure of the stream against the weir in the above question and design the weir, illustrating by a cross-section diagram.

3. How far can 100 horse-power be transmitted by a 3½-in. new, straight, smooth iron pipe, laid on a grade of 1 in 2 000, with a loss of head of 25%, under an effective pressure head of 750 lb. per sq. in.

4. A dock wall, plumb at the rear with a face batter of 1 in 24 is 20 ft. high and 9 ft. thick at the base (bottom of stream). The water in front varies in depth from 10 ft. to 18 ft. The masonry of the wall weighs 125 lb. per cu. ft., and it is founded in earth weighing 112 lb. per cu. ft., having an angle of repose of 32 degrees. Find the least depth of foundation required.

5. A wall is to be 20 ft. high and 4 ft. thick at the top to retain earth with a surcharge of 10 ft., having a slope upward from the top of the wall of 1 to 1, the natural slope of the earth being 45 degrees. What should be the thickness of the wall at the bottom and the batter, if the back is to be vertical? Take the weight of the masonry at 130 lb. and that of the earth at 120 lb. per cubic feet.

6. Make an estimate of the total cost of excavating a ditch for a canal feeder, bottom width 5 ft., side slopes 1½ to 1, depth 6 ft., length 2¼ miles, through country approximately level. The soil for most of the distance consists of 3 ft. of sand and gravel overlying stiff clay, but for ¼ mile the feeder will pass through a ledge of hard shale and slate that comes to the surface with a dip of 45 degrees. The average overhaul is ½ mile and the time allowed for the work is 90 days. Give answer in detail.

ONE SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

PROMOTION EXAMINATION FOR FIRST ASSISTANT CIVIL ENGINEER.

DIRECTIONS: You are required to answer *six* of the following questions. Give a full discussion of each question you choose to answer. You will be allowed to use any books of reference you choose, blue-prints, diagrams and slide-rules. Time allowed, 8 hours.

1. Give the force required, method and approximate cost of making a survey for macadam road 7 miles long, 5 miles being over an existing country highway and 2 miles through unwooded farm lands, the survey over the latter to cover a strip 200 ft. wide; contour interval, 2 ft.

2. Give the force required, method and approximate cost (*a*) of making a topographic survey of 20 miles of a river valley, the stream being 500 ft. wide, depth of water 8 ft.; banks of the stream low, sloping up to high cliffs 1 000 ft. back from stream; contour interval, 2 ft. (*b*) of taking soundings across stream every 1 000 ft.

3. A concrete overflow dam is to be built in a rock gorge 800 ft. wide; height of dam, 40 ft.; flood, 3 ft. deep on spillway. Draw free-hand, approximately to scale, a section of the dam, and give in detail the method used to determine its stability.

4. Sketch and describe, giving reasons, the cross-section and foundation of a concrete retaining wall, 3 ft. wide on top; earth embankment on bank level with top; water 10 ft. deep, 1 ft. below top in front; foundation in compressible material.

5. Sketch a cross-section of a macadam road in side-hill location, stone surface to be 14 ft. wide for medium traffic. Describe and give reasons.

6. Describe a design and give a sketch of a coffer-dam resting on a bare rock foundation, to resist a head of 15 ft. of water. Give reason for design.

7. Write a brief specification for building a macadam road, covering excavation, embankment and broken stone. How would you determine when (*a*) the foundation and (*b*) the broken stone has been sufficiently compacted? (*c*) How would you repair a trap-rock road when the surface has become raveled during dry weather, (*d*) when ruts have formed?

8. If a plan for a bridge abutment showed it on a gravel foundation and you found quicksand in its place when you came to build, how would you proceed with the abutment?

9. What special precautions would you take in building a concrete wall of large cross-section (*a*) in zero weather; (*b*) in hot weather? (*c*) What general precautions would you take to insure first-class workmanship at minimum expense?

10. Write a brief specification, including material and method of bonding, for a canal embankment of earth, having a puddle-wall 3 ft. thick running lengthwise of it.

11. Show a sketch of the timber forms in which is to be built a concrete retaining wall 20 ft. high, 3 ft. thick at top, 9 ft. thick at base, giving dimensions and spacing of timbers.

12. Describe several methods of constructing and finishing the exposed face of a concrete wall. State which in your opinion is the preferable method, and why.

EXAMINATION FOR ASSISTANT ENGINEER.

1. The following sections have been taken at distances of 50 ft. apart, showing deepening of a canal in rock work:

Section	1	2	3	4	5	6	7	8	9	10
Area, sq. ft........	34	18	23	41	..	8	16	43	13	17	5

Using the prismoidal formula, compute the amount due the contractor, at $2.25 per cu. yd.

2. The length *A B* of one side of trapezoid being known, and the opposite angles *A C B, B C D, C D A* and *A D B* being measured, how would you proceed to obtain the length of the opposite side *C D,* by computation?

3. Find the number of revolutions per minute of a driving pulley 3.5 ft. in diameter to transmit 6 HP., the difference in the pulls on the taut and slack sides of the belt being 150 lbs.

4. Find the position of the center of gravity of a semi-circle.

Make a drawing, in plan and elevation, of a cylinder with a circular base and show how you would find the true dimensions of a section made by a plane cutting the axis at an angle of 45°.

6. Find the horse-power of an engine that will discharge 10 000 000 gallons of water per day from a depth of 40 ft. and with a velocity of 2 ft. per second.

7. A foot bridge of span 24 ft., having three 8-ft. panels; length of vertical posts 3 ft., carries a load of 100 lbs. per sq. ft. Find the stresses in the several members, showing which are in compression and which in tension.

8. Find the moment of inertia of a square plate about an edge. Also the radius of gyration.

9. Find the greatest allowable depth of water in a circular tank 20 ft. in diameter if the pressure on the metal plates of which the tank is built is not to exceed 1 ton per sq. in.

10. How do you estimate in pounds per square inch the water pressure corresponding to a given head expressed in feet?

11. A creek is carried under a canal, through three flat-bottomed, semi-circular culverts, with a diameter of 10 ft. each. Owing to a deepening of the canal of one foot it becomes necessary to carry the creek through two rectangular culverts of equal width and each 4 ft. high. What should be the width of each rectangular culvert in order to have the same aggregate carrying capacity as with the three semi-circular culverts, the grade remaining the same?

12. A culvert having a slope of 1 in 100 must take the drainage from 1,000 acres. How many cubic feet per second must be carried by the culvert, using the formula,

$$Q = c\,y\,\sqrt[4]{s\,A^3},$$

where

Q = cubic feet per second reaching culvert.
c = proportion of rainfall reaching culvert.
y = rainfall per hour.
s = average slope of watershed in feet (per 1 000 ft. horizontal distance).
A = acres of watershed = 1 000 in this instance?

(Give values to c, y and s according to your judgment of what they should be.)

LEVELER.

$4.50 to $5 a day.

Candidates must have had at least two years' practical experience in civil engineering. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Theoretical and practical questions, including mensuration and use of logarithms, plane trigonometry, topographical surveying, mapping and leveling, elementary mechanics and hydraulics, theory and use of rod, level and transit, and highway construction, 5; experience and personal qualifications, 3; education, 2. Time allowed for the written examination, 8 hours. Books of reference will be permitted as for assistant engineer, above.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Leveler.

Held at.................... Date......................
Time commenced...........
Time finished.............. Examination No............

Directions: Time allowed for the whole written examination, 8 hours. Answer questions on blank paper provided, not on this sheet. Number the answers to correspond with the numbers of the questions. In the case of problems, all the work of solution must be given. Slide-rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used in answering the questions of this sheet. Do not pass the tables to any other candidate, but return them to the examiner. Answer all of the following.

1. Describe the chief differences between Portland and Rosendale (or natural) cement. Give in detail the best method of mixing Portland concrete "by hand."

2. What are the most important requirements for which provision must be made in the construction of a macadam highway? In what ways is macadam most likely to fail?

3. Write a brief set of specifications for the stone to be used in a macadam highway.

4. What materials make the best binder for a macadam road? Describe in detail the proper method of applying the binder.

5. Describe in detail the "stadia" method of making a topographical survey. What are its advantages?

6. The survey of the boundaries of a large tract of land is made with a transit and tape. Discuss the compensating and cumulative errors that are likely to occur and explain the precautions you would take to overcome or reduce the latter.

7. The valve in the gate of a canal lock is 10 in. sq., and its center is 2 ft. below the water level on one side and 10 ft. below the water level on the other side. The valve and rod together weigh 10 lb. The valve-rod is attached to a lever 15 in. from its fulcrum, and the force to open the valve is applied 40 in. from the fulcrum. If the coefficient of friction is .49, what force is required to open the valve?

8. *M* is accessible, but is hidden from *N*. *N* is inacessible, but can be seen from *P* and *R*. Find the distance from *M* to *N*, the following additional data being given:

Course	*MP*	= 368.25 ft.,	bearing	N. 28° 42′ W.
"	*PR*	= 465 ft.,	"	S. 32° 10′ W.
"	*RN*		"	S. 89° 4′ W.
"	*PN*		"	S. 62° 15′ W.

9. A piece of 3 by 4 in. clear spruce lumber 13 ft. long is used as a lever with fulcrum 4 ft. from one end. What is the greatest load that may be applied at the other end before the beam breaks if the ultimate tensile strength of the timber is 10 000 lb. per sq. in.?

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Leveler.

Directions: In answering the questions on this sheet any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. A pillar 14 ft. in height is to be built up of rolled I-beams and plates and is to support a total load of 30 tons. Using 6 as a factor of safety, design the pillar, illustrating with a free-hand, pencil, cross-section sketch, giving dimensions.

2. A canal feeder in firm gravel and earth free from weeds and rock has a bottom width of 5 ft. and sides sloping 45°; the longitudinal slope of the bottom is 1 in 1 000, and the depth of the water is 5.5 ft. Find the flow in cubic feet per second.

3. The wall of a canal lock is to be of limestone masonry 24 ft. in height above 2 ft. of concrete. The land on which it is to be built consists of 18 ft. of marsh and soft loam overlying clay. Determine the size and number of piles per square yard required to support it.

4. A triangular weir has sharp edges and sides sloping 45° with the vertical. Find the flow in cu. ft. per minute when the velocity of approach is 0 and the head over the angle of the weir is 10 in.

(2 Sheets) Last Sheet.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Leveler.

Directions: Answer questions on blank paper provided, not on this sheet. In answering the questions on this sheet, any books of reference may be used. When such books are used for formulas, tables of constants, etc., candidates will give the name of the book and the page referred to. Give computations in full. Answer all of the following:

1. In order to find the quantity of water conveyed by a ditch 3 ft. wide a weir with a rectangular notch 2 ft. wide and 1 ft. deep, with sharp edges, is placed across the ditch, causing the water to have a depth of 2¼ ft. above the bottom of the ditch and 8½ in. above the crest of the notch. Find the discharge in cubic feet per second.

2. What depth and bottom width should be given the transverse profile of a canal feeder whose banks are of coarse gravel with a few weeds and slope at 40° to the horizontal, in order that it may conduct 75 cu. ft. of water per second with a mean velocity of 3 ft. per second? The feeder has a fall of 2 in 1 000.

3. A canal in clean, coarse gravel is 20 ft. wide at the bottom and its side slopes are 1½ to 1; it has a longitudinal slope or fall of 1 in 360 and a depth of 8 ft. If a submerged weir 2 ft. high be built across the canal, what will be the increase in the depth of the water?

4. The horizontal section of a canal lock has an area of 12 150 sq. ft., and the difference of level between the surfaces of the water in the lock and in the upper reach is 9 ft. Each of the two gates is to have one sluice or valve whose center is to be 20 ft. below the surface of the upper reach, and the water is to be leveled up in 2 minutes 48 seconds. Determine the proper area of each valve.

5. A cast-iron beam of rectangular section, 12 in. deep, 6 in. wide and 20 ft. long, carries, in addition to its own weight, a single load P; the safe allowable tensile stress is 2 000 lb. per sq. in. Find the maximum allowable value of P when it is placed (*a*) at the middle point; (*b*) at 2½ ft. from one end.

6. A hollow cast-iron pillar 12 ft. in height has to support a dead load of 35 000 lb. and a live load of 20 000 lb.; its internal diameter is 6½ in. Find the required thickness of the metal, taking 6 as the factor of safety.

1st Sheet same as Assistant Engineer (see *ante*).

EXAMINATION FOR LEVELER.

1. Give a form of level note book showing cuts necessary to lay a pipe having a slope of 0.88 to 100, the cut at station zero being 10 ft.; assume 6 stations 25 ft. apart, the pipe rising from station zero.

2. A grade of 1-270 is how much per 100? How much per mile?

3. An ellipse has axes of 12 ft. and 6 ft. What is the radius of a circle having an area equal to that of the ellipse?

4. Explain various practical methods of finding, graphically, or otherwise, the area of a figure with irregular curved lines as boundaries.

5. What effect will be produced on the derived heights of a series of bench marks, where a New York rod has been used having .002 ft. worn off the lower end?

6. Construct a right-angled triangle being given the hypothenuse = 6 in. and the tangent of one of the angles = 0.5.

7. In making a survey the angles A, B of a triangle $A\ B\ C$ were found to be 10° 12′ and 46° 36′ and the side $B\ C$ 500 ft. Compute the other sides.

8. Make an estimate of the cost of a cubic yard of concrete, in which the cement costs 78 cts. per bbl., the sand costs $1 per cu. yd., the broken stone costs $1.35 per cu. yd., the water 10 cts. per 1 000 gallons and $\frac{3}{8}$ of a day's labor is required at $1.50 per day. Use quantities which you think should constitute the proper proportions of the different materials.

9. Draw a plan and elevation of a cylinder with a circular base.

10. A bridge 20 ft. long weighs 5 tons. A wagon weighing 1 ton is 6 ft. from one end of the bridge. Find the total loads carried by the abutments, stating the amount carried by each.

11. Express a discharge of 1 cu. ft. per second in gallons per minute.

12. Compute by finding the latitudes and departures, the area of a field from the following notes:

Station.	Bearing.	Distance in Chains.
1	N. 52° E.	1.28
2	S. 29° 45′ E.	8.18
3	S. 31° 45′ W.	15.36
4	N. 61° W.	14.48

RODMAN.

$3.50 to $4 a day.

Subjects of examination and relative weights: Theoretical and practical questions, including mensuration and use of logarithms, plane trigonometry, elementary surveying, leveling and mapping, theory and use of rod, level and transit, and highway construction, 6; experience and personal qualifications, 1; education, 3. Time allowed for the written examination, 6 hours.

(2 Sheets) Sheet No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Rodman.

Time allowed for the written examination, two sheets, 6 hours. Answer questions on blank paper provided, not on this sheet. Logarithmic work and other computations must be shown in full. Slide-rules may be used to check results. Logarithm tables will be furnished by the examiners; no other books may be used. Do not pass the tables to any other candidate, but return them to the examiner.

1. The following is a well-known formula for weir discharge:

$$q = 3.33\ (b - 0.2H)\ [(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}}].$$

Find by logarithms the value of q to three places of decimals when $b = 5$, $H = 1.24$ and $h = .18$.

2. A sand bank is 15 ft. high; the top is in the form of a circle with a radius of 5 ft.; the bottom also is circular and measures 21 ft. across. Find the number of cubic yards contained in the bank.

3. In order to find the distance from A on one side of a hill to an inaccessible point W on the other side, a line 558 ft. long is run from A to B, and another 307 ft. long from B to C, from both of which W can be seen. The following angles are measured, $A\ B\ W = 64° 17'$, $W\ B\ C = 71° 37'$, $W\ C\ B = 75° 54' 30''$. Find the distance from A to W.

4. A beam 12 ft. long rests across a narrow vertical wall at a point $3\frac{1}{2}$ ft. from one end. The longer segment of the beam supports a weight of 64 lb. at its outer end and the beam is kept horizontal by a rope from the other end which is fastened to the wall $3\frac{1}{2}$ ft. from its top and the beam is kept from slipping by a cleat underneath it. Neglecting the weight of the beam, find the tension in the rope and the vertical pressure upon the wall.

5. From the following notes of the survey of a field, calculate the area in acres.

Course.	Bearing.	Distance.
A to B	S. 69° 15′ E.	706 ft.
B to C	N. 37° 15′ E.	593 ft.
C to D	N. 39° 30′ W.	600 ft.
D to E	S. 57° 45′ W.	465 ft.
E to A	S. 30° 00′ W.	498 ft.

6. It is required, using a steel tape, to measure with great accuracy the distance between two points about two miles apart; mention and describe in detail the precautions that should be taken.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR RODMAN.

7. Mention and describe three methods employed or precautions taken to keep the subgrade of a macadam road dry. Why is it important that the subgrade be kept dry?

8. A trench for a canal feeder is to be dug, bottom 8 ft. wide with side slopes $1\frac{1}{2}$ horizontal to 1 vertical. Suppose levels have been taken on the centre line; explain in detail how you would set and mark the slope stakes.

9. What is meant by "raveling" in a macadam road? Describe in detail the means that are employed to prevent and correct it.

10. In a survey two tangents (or courses) intersect at stake 112 + 45 and the deflection angle is 40° 30′. These tangents are to be connected by a 12° curve, which is to be located by offsets from the first tangent, the points to be determined for each 50 ft. of length. Find the first three offsets and the points on the tangent from which they are to be measured.

11. Describe in detail the best method of mixing by hand concrete for the foundation of a masonry retaining wall, and state the usual proportions of the ingredients.

12. State in their proper order and explain in detail the adjustments of the engineer's transit.

13. Plot the following stadia notes to about the scale 100 ft. = 1 in., and from the points when plotted draw contour lines for

each even foot of elevation. Do not erase the points plotted after drawing the contours.

Horizontal angle.		Distance.	Elevation.
36°	34′	79.68	116.48
39	40	159.36	119.77
83	25	99.40	118.96
156	28	45.91	110.47
147	8	65.93	112.60
126	37	185.26	122.92
103	18	175.65	115.13
88	18	199.60	119.19
61	48	220.56	120.34

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF RODMAN.

1. Find by logarithms the value of d to three decimal places from the formula:

$$d^5 = \frac{q^2\,(m \sin z + 2)}{c^2\, s\,(m + \cot z)^3 \sin z}$$

when $q = 228$
$m = 1.15$
$z = 52°$
$c = 77$
$s = .0015$

2-3. From the following data find the distance from A to B correct to one decimal place.

	Bearing.	Distance.
$A\ C$	E. 33° 41′ E.	195.4 ft.
$A\ D$	N. 75° 32′ W.	129.9 ft.
$B\ C$	S. 76° 0′ E.	
$B\ D$	S. 5° 47′ E.	

4. Find correct to one decimal place the number of cubic yards of sand in a bank having a level top 5 ft. wide and 20 ft. long in the shape of a rectangle, 15 ft. long, with semi-circular ends, if the bank is 12 ft. high and has a uniform slope on all sides of 1.5 horizontal to 1 vertical.

5. The following are from the field notes of a stadia survey in which the constant correction, k, for the instrument was 1.2 ft.

Stat. No.	Stadia Reading.	Vert. Angle.
1	131.4	— 2° 37′
2	168.4	—18° 26′

Find the corrected distance and elevation for both observations by the accurate formulas:

$$\text{dist.} = \text{reading} \cos^2 a + K \cos a$$
$$\text{elev.} = \tfrac{1}{2} \text{ reading} \sin 2a + K \sin a$$

and also by the approximate formulas:

$$\text{dist.} = \text{reading} \times \cos a + K$$

and $$\text{elev.} = \text{reading} \times \sin a$$

and find the percentage of error in each case, due to the approximation.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF RODMAN.

6. State and explain in their proper order the five adjustments of the engineer's transit.

7. Sketch carefully in pencil a profile and explain how it is used in establishing the grade for a highway and in estimating and balancing cuts and fills.

8. What is meant by the "declination of the magnetic needle?" Describe the variations of the magnetic declination. In the field how would you determine the true north? Explain in detail.

9. What is the use of a binder in a macadam road? How should the binder be applied? What mistakes are sometimes made in applying the binder?

10. Discuss the proper size, shape and quality of stone to be used in the construction of a macadam road. Why are these requirements of the stone important?

11. What is meant by telford in macadam road construction? When should telford be used?

12. What will probably result if in the construction of a macadam road the following are allowed: (*a*) roots and sods in the subgrade; (*b*) poorly drained subgrade; (*c*) insufficiently rolled subgrade; (*d*) lack of crown to road; (*e*) soft and hard stones used together in the road?

EXAMINATION FOR RODMEN.

In this and the examinations for Leveler and Assistant Engineer below, the work of computation must be shown. (Books of tables are furnished by the Board for the use of the candidates and no other books are to be used.)

1. Divide $\frac{3}{8}$ by $\frac{4}{16}$.

2. Multiply 0.3642 by 0.0072.

3. Extract the square root of 0.00000.

4. Reduce 325° 46′ 23″ to seconds.

5. Find eleven times the sum of $23° 00'$ less $10''$ and $0° 02\frac{1}{2}'$ less $57''$.

6. Having the area of a circle, how would you find its diameter?

7. Having one diameter and the area of an ellipse, how would you find the other diameter?

8. Find the values of x and y from the equations:

$$\begin{aligned} x^2 + y^2 &= 25 \\ x + y &= 7 \end{aligned}$$

9. What is the length in rods of the side of a square which contains $59\frac{3}{8}$ acres?

10. If the grade of a railroad is 73 ft. in a mile, how much is it in each 100 ft.?

11. A distance of 5 280 ft. has been measured on an even incline of 3 to 100, what is the correct horizontal distance?

12. A tank measures 7 ft. 9 in. long by 6 ft. 4 in. wide by 8 ft. 4 in. deep. If water flows into this tank at the rate of 1 gal. in 3 seconds, how long a time will it take to fill the tank, and what will be the entire pressure on the bottom of the tank?

13. An earth embankment measures, in embankment, 1 693 cu. yd.; the material shrinks in embankment 6%. How much would it have measured in the original bank from which it was taken?

14. A barn is 40 ft. wide. The pitch of the roof is 45°; find the length of the rafters.

15. Give the approximate weights of 1 gal. water, 1 cu. ft. water, 1 cu. ft. cast iron, 1 cu. ft. granite, 1 cu. ft. brick.

16. Taking a kilogram to be equivalent to 2.2 lb., find the number of grams in 1 oz.

17. A gravel bed has a surface of 6 acres and an average depth of 6 ft. How many miles of road can be covered with this gravel to a width of 11 ft. and a depth of 6 in.?

18. Express a speed of 10 miles an hour in centimeters per second.

19. In the Phœnix Iron Co.'s pocketbook it is stated that the specific gravity of cast iron is 7.2; what does this mean?

CHAINMAN.

Minimum age, 18 years. $2.50 to $3 a day. Subjects of examination and relative weights: Arithmetic, mensuration and use of chain, 8; experience and education, 2. Time allowed for the written examination, 6 hours.

1 SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF CHAINMAN.

Answer questions on blank paper provided, not on this sheet.

1. A wall 1 690 ft. long is to be built in 30 days, and it is found that 7 men in 14 days have completed only 490 ft.; how many additional men must be employed for the remainder of the time so that the wall may be completed in the required time?

2. Find the cubic yards of masonry in a wall 88½ ft. long, 10 ft. high, 1 ft. 6 in. thick at the top, 3 ft. 6 in. thick at the bottom, with sides sloping uniformly from the top to the bottom.

3. Two adjoining lots of city land 132 ft. deep contain respectively 31 sq. rd. 112½ sq. ft., and 35 sq. rd. 36 sq. ft. These two lots together are to be redivided into five equal building lots. What will be the width in feet of each lot?

4. If the rainfall on a certain day was ½ in., how many gallons of water fell on a rectangular piece of land 22 rd. 9 ft. wide and ¼ mile long? (1 gal. contains 231 cu. in.)

5. What is the length of an arc of 30° in a circle whose diameter is 18 ft.? (Give answer to 3 decimal places.) (The circumference is 3.1416 times the diameter.)

6. (*a*) If you were sent to make a chain survey of a piece of rough meadow land what tools or instruments would you need to take with you? (*b*) Explain carefully and in detail how you would begin the work and how proceed with the measurement of the first course? (*c*) How would you keep the measurement always in a straight line with the points from which and to which you are chaining?

7. Suppose that you have arrived at a corner or angle in the meadow and have with you neither transit nor surveyor's compass, how would you measure the angle in the line you are chaining so that a map could be made from the measurements and notes you are taking?

8. (*a*) How would you proceed if your line crosses a broad gully very steep on one side. Explain carefully and in detail. (*b*) Suppose that your line passes over a hillock that shuts out from view the rod toward which you are chaining; how would you overcome the difficulty? (*c*) How would you proceed if a large tree stood in the way of the line you were chaining?

9. (*a*) What would you do if a 100-ft. length, in your measurement, should end in the middle of a brook that flows swiftly over a smooth stone bottom? (*b*) What would you do if your line crossed a bed of quicksand or a deep marsh more than a chain length across? Explain carefully.

10. (*a*) How would you lay out a line at right angles to the course you have just measured? (*b*) Having finished your survey, how would you fold your chain?

11. If your 100-ft. chain is $\frac{5}{8}$ in. too short what is the true length of a line that you have measured and recorded as 2 416.5 ft. in length?

12. Have you had any experience as chainman or assistant in a survey? If so describe in detail, giving time, place and length of service. What experience or other education have you had that you consider qualifies you for duties of chainman?

(ONE SHEET.)

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF CHAINMAN.

DIRECTIONS: Answer questions on blank paper provided, not on this sheet.

N. B.—In solving problems the entire process and entire computation must be given on the answer sheet handed in. Mark the answer to each problem: "Ans."

1. The sides of a triangular field, one of whose angles is a right angle, are respectively 36, 48 and 60 rods; how much is it worth at $75 an acre? (160 sq. rd. equal 1 acre.)

2. If 8 yd. of cloth 1¾ yd. wide cost $30, what will be the cost of 14¾ yd. of cloth of the same quality, 2¼ yd. wide?

3. A line was measured and recorded as 1 mi. 60 rd. 2 ft. in length. It was afterwards determined that the 100-ft. chain, with which the line was measured, was .7 in. too long; what was the true length of the line?

4. Find the cost of 50 boards, each 16 ft. long, 8 in. wide and 1½ in. thick, at 2½ cents per ft., board measure.

5. A railroad train ran 56.3 miles in the first hour, 62.34 miles in the second, 59.247 miles in the third, and 60.7304 miles in the fourth. Find the average rate of speed per hour.

6. Take .794569376 from 15.6000304.

7. If the steel of which a tape is made expands .00001082 of its length for each degree increase of temperature, what will be the length of a steel tape at 43.5 degrees if its length at 0 degrees is 99.897 feet?

8. A rectangular field contains $1\frac{1}{16}$ acres; what is its length if its width is 175.25 ft.? (One acre equals 43 560 sq. ft.)

9. A rectangular field 7½ times as long as it is wide contains 300 acres. What is the distance around the field?

10. Describe in detail how two chainmen using chain and pins would measure the exact distance between two fixed points across a field which is level or nearly so.

11. How are angles measured by use of the chain alone?

12. Describe a good method of taking offsets with a chain in order to pass obstructions, such as buildings or large trees. Use diagram to illustrate your answer.

13. How could you lay off on the ground an angle of 60° by means of the chain alone? An angle of 90 degrees?

14. What are the principal sources of error in chain measurements?

15. What advantages has the steel tape over the chain for accurate measurements?

EXAMINATION FOR CHAINMAN.

1. What is the length of a surveyor's chain?

2. How many feet are there in a quarter of a chain?

3. Add $5\frac{1}{2}$, $3\frac{1}{8}$ and $7\frac{1}{4}$.

4. Divide 5 280 by 66.

5. Make a sketch showing the points of the compass.

6. Find the number of cubic feet capacity of a box whose inner dimensions are length 16 in., breadth 16 in., and depth 13.5 in.

7. If a tape line is divided into feet and tenths, how many tenths will there be in $15\frac{1}{2}$ ft.?

8. What will 42 642 bricks cost at $6.50 per 1 000?

9. Describe the process of measuring distances with a tape line or chain, on hilly ground.

10. What are grade stakes and how are they driven?

ENGINEERING DRAFTSMAN.

$4 to $5 a day.

Subjects of examination and relative weights: Practical and theoretical questions, including mensuration and the solution of plane triangle, use of logarithms, free-hand lettering, reduction of field notes and plotting, mapping, 7; experience and education, 3. Time allowed for the written examination, 8 hours.

SPECIMEN QUESTIONS.

DIRECTIONS: The work of computation must be shown in full. Logarithm tables will be furnished by the examiners.

1. Two straight roads meet at an angle of 58½ degrees. Find the distance betwen a tree on one of the roads a half-mile from their point of meeting, and a flag-pole on the other road 3 640 ft. from the same point.

2-4. From the following bearings and distances, balance the survey, plot to suitable scale and compute the area in acres by the method of co-ordinates:

Station A..........	N. 51° 50′ E.	Distance, 1,063 ft.
Station B..........	S. 29° 45′ E.	Distance, 410 ft.
Station C..........	S. 31° 44′ W.	Distance, 769 ft.
Station D..........	N. 61° 0′ W.	Distance, 713 ft.

Letter the bearings and distances on your map in stump writing.

5. Indicate the following by means of neat free-hand pen drawings, each to occupy a space 1 in. by 1½ in.: (*a*) quarry-faced masonry; (*b*) brickwork in Flemish bond; (*c*) broken range masonry; (*d*) forest with both evergreen and deciduous trees; (*e*) marsh with stream through it.

6. Draft the following title in letters of three different sizes, using stump or round writing or some other style of free-hand lettering that you can do neatly and rapidly: "Plans for improving the highway between Buffalo and Albany, a distance of 310 miles, passing through Medina, Rochester, Clyde, Syracuse, Oneida, Whitesboro, Utica, Little Falls and Schenectady. Scale 1 in. = 100 ft.

7-8. Draw plan, elevation and cross-sections for a semi-circular arch-culvert, of 15 ft. span, under a highway 22 ft. wide, allowing 2 ft. between the top of the arch and surface of road, with parapets 2 ft. 6 in. wide, 3 ft. high. Design suitable wing-walls for a flood 3 ft. deep. Supply all other needed data.

9-10. Draw 5-ft. contour lines from the elevation points given on this sheet; mark the elevations for each contour and indicate the probable location of streams.

From the contour sheet as you have prepared it, draw on separate sheet two sections of the ground, one through the line N. S., the other through E. W. Indicate the vertical scale used.

(2 SHEETS) SHEET No. 1.

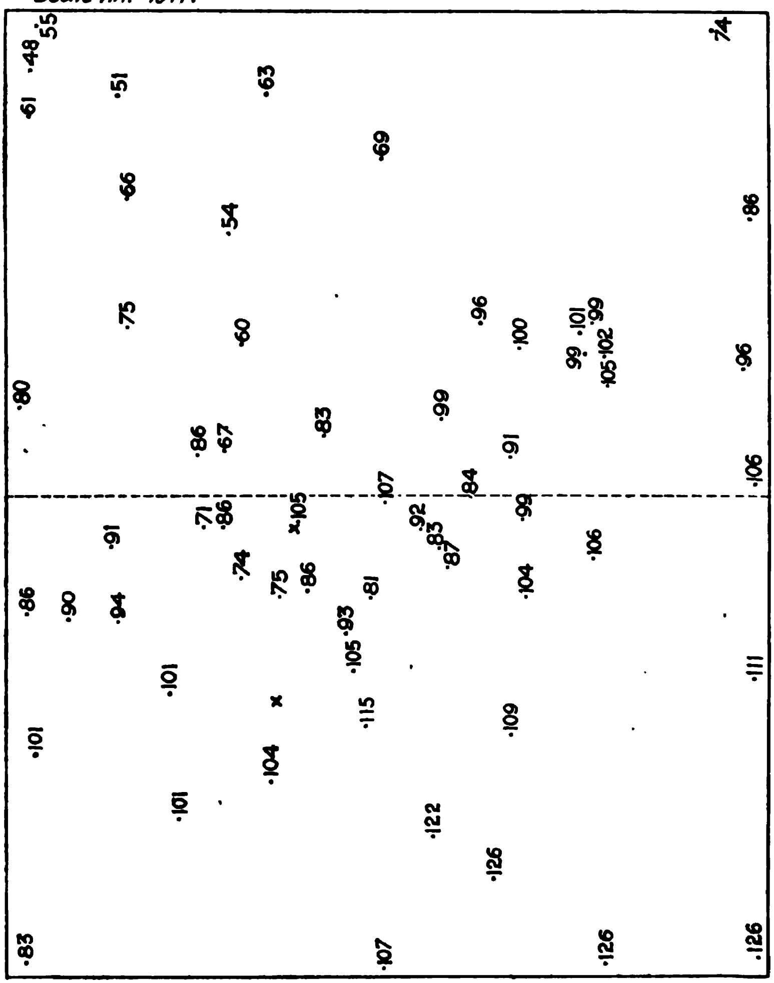
STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR CIVIL ENGINEERING DRAFTSMAN.

Time allowed for whole examination, 8 hours.

1-2. Draw 5-ft. contour lines (at 90, 95, 100 ft., etc.) from the elevation points given on this sheet; mark the elevation of each contour and indicate the probable location of streams. Ink in contours.

Scale 1in.=10ft.



3-4. Design an arch culvert with roadway 12 ft. wide with suitable wing walls to occupy the location indicated by the red x's on the accompanying contour sheet. The elevation of the roadway over the culvert is to be 104.

5. Draft the following title in letters of suitable sizes, using stump or some other style of free-hand lettering that you can do neatly and rapidly:

"Section Map Showing Location of Culvert No. 3, Pierrepont Manor and Ellisburgh Road. Scale 1 in. = 10 ft."

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR CIVIL ENGINEERING DRAFTSMAN.

DIRECTIONS: Answer questions on ruled or drafting paper provided; the work of computation must be shown in full. Logarithm tables will be furnished by the examiner; no other books may be used. Do not pass the tables to any other candidate, but return them to the examiner.

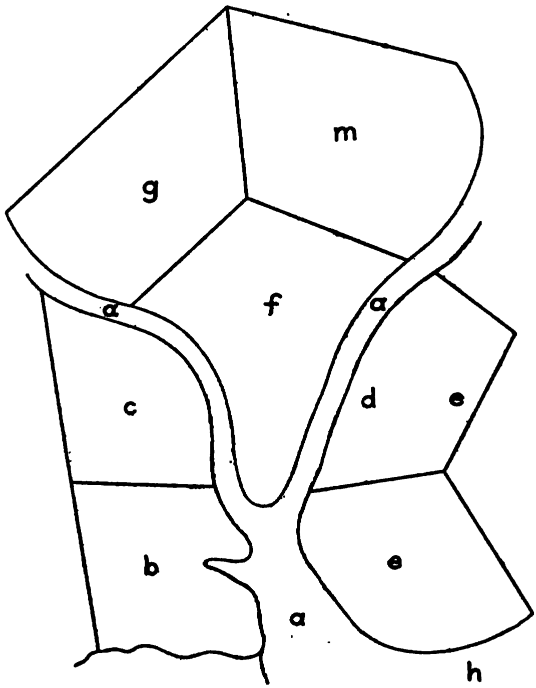
6-7. Plot the following stadia notes, after making the necessary correction, to the scale 1 in. = 40 ft. Distances must be correct to the nearest tenth of a foot; elevations and contours are not called for. The constant for the instrument is 1.2 ft.

OBSERVATIONS AT STATION A.

Shot No.	Stadia reading.	Horizontal angle.	Vertical angle.
1	127.8	86° 29′	— 0° 32′
2	199.5	33° 41′	— 9° 22′
3	168.4	326° 32′	—18° 26′
4	131.0	284° 28′	—11° 38′
5	131.4	212° 50′	— 2° 37′
6	161.8	180° 3′	0° 0′
7	177.7	154° 27′	+6° 7′

8-9. Copy the accompanying map to the scale 1 in. equals 2 miles, and in place of the letters, fill in the proper topographical signs to indicate: (*a*) water; (*b*) marsh with stream; (*c*) hops;

(*d*) cliff; (*e*) hills with deciduous trees; (*f*) meadow; (*g*) fallow, or rough cleared land; (*h*) sand bar; (*m*) farm with buildings, etc.



Scale 1" = 3 Miles

10-11. Problem 6-7 gave the stadia shots from Station A of a survey. Station A is invisible from Station B. In order to locate Station B, the transit, set up at B, was turned back on the points numbered 1 and 2 of observations from A and the following horizontal angles were read:

"Shot No. 1." 128° 29′ "Shot No. 2." 104° 0′

Find the distance and bearing of the course AB.

BRIDGE DESIGNER.

$1 500 to $1 800.

Candidates must have had at least five years' practical experience in drafting, designing and constructing structural steel and bridge work. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Questions on graphical and analytical determination of stresses in simple highway trusses and plate girders, and design of plate girders, floor beams, truss members, foundations, bearings, etc., with drafting, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired. The Carnegie and Pencoyd handbooks are suggested. Time allowed for written examination, 8 hours.

SPECIMEN QUESTIONS.

Theoretical and Practical Questions.

1. Find the stresses analytically in a through skew Pratt truss of 7 panels, the axis of the truss making an angle of 60° with the abutments, the 5 middle panels being each 25 ft. long, and the end panels 30 ft. and 20 ft. respectively. Height 30 ft.; width 20 ft. in the clear. Dead load 1 000 lb., live load 4 000 lb. per lin. ft.

2. The accompanying figure represents the half-truss for a bridge of 80-ft. span, depth at B and at center $=$ 12 ft., depth at A $=$ 6 ft. Find graphically the stresses in each member due to a load of 5 tons at each panel point, divided between two trusses.

3. Find the stresses in a parabolic arch bridge of 10 panels; span 120 ft., rise 24 ft., hinged at both ends and at the middle joint. Dead load 1 000 lb., live load 2 000 lb. per horizontal foot.

4. Find the tension at the middle and ends of each cable of a suspension bridge of 200 ft. span. Dip of cables 80 ft., weight of roadway ½ ton per ft., live load ½ ton per ft. Show by a free-hand drawing how the cables should be anchored.

5. The counterbalanced swing-bridge, shown below, is 16 ft. deep and wholly supported upon the turn-table at A and B; the dead weight is 650 lb. per lin. ft. The counterpoise is hung from C and D; find its weight, assuming that a portion of it is transmitted to A through B E, sufficient to make the reactions at A and B equal.

6. The members of a bridge consist of 4 eyebars 4 in. by $1\frac{3}{16}$ in. on one side of a panel point, 2 eyebars 4 in. by $1\frac{7}{16}$ in. on the other side, the diagonals are $1\frac{9}{16}$ in. thick, half the post is $\frac{7}{8}$ in., the vertical compression in the half post is 40 000 lb. for full loading; assuming the unit stress at 10 000 lb. per sq. in., calculate the size of the pin required and pack the pin.

7. Give a short description of the kind of floor system you consider best suited for city bridges subject to heavy loads. What is the usual allowance for clearance under city bridges?

8. How do you proportion expansion rollers?

9. If you were sent out to inspect and report on an existing structure, what are the principal points you would investigate and how would you proceed to do it? What are the principal points to be observed in painting a bridge?

10. A plate girder of 64 ft. span and 8 ft. depth carries a load of 2 tons per lin. ft. At any section the two flanges are of equal area and their combined area is equal to that of the web. Find the sectional area at the center of the girder so that the intensity of stress in the metal may not exceed 3 tons per sq. in. Design the girder and illustrate by carefully-made drawings.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR BRIDGE DESIGNER.

Held at..................... Date.........................
Time commenced...........
Time finished................ Examination No.............

Answer questions on blank paper provided, not on this sheet. Logarithm tables will be furnished by the examiner, but no other books may be used in answering the questions of this sheet. Time allowed for the whole written examination, 8 hours.

1. Discuss the arguments for and against the use of double and triple system trusses in railroad and highway bridge design.

2. Calculate analytically the stresses in a double system through Warren truss, 125 ft. long and 18 ft. deep, of 10 panels each, 12.5 ft. long, due to a uniform dead load (for each truss) of 800 lb. per lin. ft. Place results on a truss diagram.

3. Determine graphically the stresses in a through bridge truss of 7 panels each 27 ft. long, of the Pratt type, but with a broken upper chord, making the verticals respectively 29 ft., 35 ft., 38 ft., 38 ft., 35 ft. and 29 ft., due to a dead load of 1 200 lb. per lin. foot, of which 400 lb. is to be carried by the upper chord.

4. A through Pratt truss has 9 panels each 24 ft. long and 32 ft. deep. The dead panel load is 2.4 tons on the upper chord and 5.6 tons on the lower chord and the live panel load is 18 tons. Compute the maximum and minimum stresses in the fourth vertical and in the main and counter diagonals in the fourth panel.

5. Design, making plan, elevation and section drawings for a bridge pier, including its foundation on soil consisting of 2 ft. of silt and 10 ft. of sand overlying hardpan; the bottoms of the trusses, each 140 ft. long, are to be 35 ft. above the surface of the water, which is 9 ft. deep. By the proper conventional signs, indicate the materials of construction.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

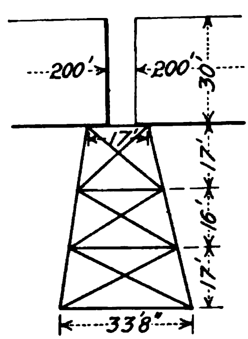
EXAMINATION FOR BRIDGE DESIGNER.

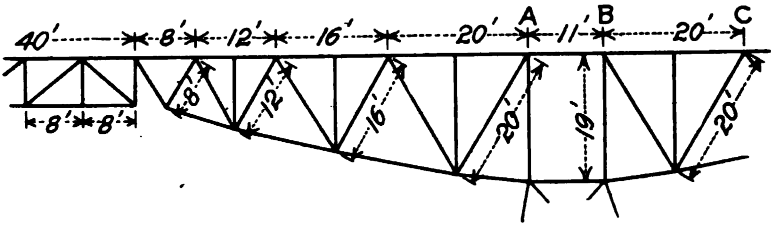
In answering the questions of this sheet, any books of reference may be used. When formulas or constants are taken, give the book and page where they are found.

6. Design a steel column 30 ft. high to sustain a dead load of 120 tons and a live load of 100 tons, without external bracing. Make to scale diagram of its cross-section and give all required computations.

7. A floor beam of soft steel in a railroad bridge has a span of 16 ft. and weighs 2 600 lb. Each stringer is 22 ft. long and weighs 3 800 lb. The stringers are spaced 7 ft. apart. The track is to be taken at 450 lb. per lin. ft. The maximum floor beam reaction due to the live load is 46 600 lb. The floor beam has a web $\frac{7}{16}$ in. thick and an effective depth of 38 in. or $39\frac{1}{2}$ in. out to out. Compute the rivet spacing in the flanges. How many changes in rivet pitch would you adopt? Assume the proper working stresses.

8. The accompanying figure represents a pier, square in plan, supporting the ends of two deck trusses, each 200 ft. long and 30 ft. deep. The height of the pier is 50 ft. and is of three panels as shown. Ten sq. ft. of bridge surface and 10 sq. ft. of train surface per lin. ft. are subjected to a wind pressure of 40 lb. per sq. ft. The center of pressure for the bridge is 68 ft., and for the train 86 ft. above the base of the pier. The wind produces also a horizontal pressure of 4 000 lb. at each of the intermediate panel points on the windward side of the pier. Width of pier, 17 ft. at top and 33 ft. 8 in. at bottom. Dead load of bridge 1 600 lb. per lin. ft. and live load 3 000 lb. per lin. ft. Draw a diagram giving the wind-stresses in all the members of the pier and indicate which are in compression and which in tension.





9. The above diagram represents one of a pair of cantilevers that support a free Pratt truss of 5 panels each 8 ft. long and 7 ft. deep. The cantilever is made up of eight equilateral triangles of sides respectively 8 ft., 12 ft., 16 ft., 20 ft., 20 ft., 16 ft., 12 ft., and 8 ft., and a pier panel 11 ft. long and 19 ft. deep. Find the maximum stresses in the chords A B and B C, due to a live load of 600 lb. per lin. ft. per truss crossing the bridge.

10. A deck plate girder bridge for a double-track railroad, span 120 ft., effective depth 140 in., is to be designed in 10 panels or sections of equal length. Find the shear and required web-section in an end panel and the bending moment and required flange-section in the fourth panel from one end for one girder due to live loads composed of two standard engines, described below, followed by a uniform trainload of 3 600 lb. per lin. ft. Pilot wheel loads 18 000 lb.; driver loads, 34 000 lb.; tender loads, 21 000 lb.; from pilot wheel to driver, 8 ft.; four drivers spaced 5 ft. apart; drivers to tender 8 ft.; four tender wheels spaced 5 ft.; from tender to next engine, 8 ft.; from second tender to train, 4 ft.

BRIDGE DRAFTSMAN.

$1 200 to $1 500.

Candidates must have had at least three years' practical experience in drafting on structural steel and bridge work. Candidates who have graduated in civil engineering from a school maintaining a standard satisfactory to the Commission will be credited with one year of the required experience. Subjects of examination and relative weights: Questions on riveted joints, standard bridge details, roller bearings, conventional signs and drawings, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired. Time allowed for written examination, 8 hours.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR BRIDGE DRAFTSMAN.

DIRECTIONS: Logarithm tables will be furnished by the examiner; no other books may be used in answering the questions of this sheet. Time allowed for the written examination, 8 hours.

1. In some neat, suitable style of free-hand lettering, write the title, "Design and Specifications for a Double System Warren Highway Bridge, Span 128 ft."

2. Find the web and chord stresses in a through riveted Warren highway truss of 5 panels, each 20 ft. long and 15 ft. high, due to a dead load of 10 000 lb. per panel, 7 000 lb. of which is to be taken by the lower chord and 3 000 lb. by the upper chord.

3. The above bridge is to have a width in the clear of 18 ft. and the live load is to be taken at 96 lb. per sq. ft. of floor. Design the floor beams and stringers and show how they should be attached to the other members of the bridge.

4. Design a suitable ornamental entrance for a through city highway bridge which shall be made of standard shapes or simple modifications and shall serve also as portal bracing. Make detail drawings, if necessary, to show how this shall be constructed.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR BRIDGE DRAFTSMAN.

In answering the questions of this sheet, any books of reference may be used.

5. Design a deck plate girder, span 80 ft., depth 6 ft., which is to be one of two girders to support a highway span 18 ft. wide on which there may be a live load of 90 lb. per sq. ft. Make plan, elevation and section drawings to the scale 1 in. equals 4 ft., showing method of building up the girder, of attaching the lateral bracing, etc.

6. Give in detail the calculations for the determination of the flange area, allowance for rivets and numbers of rivets near the center of the above plate girder.

7. In a riveted Pratt truss of 9 panels, each 16 ft. long and 18 ft. deep, the following maximum stresses have been determined in tons, + meaning tension, — meaning compression. The stresses in the first five panels are, upper chord — 73.2, — 94.2, — 104.7, — 104.7; lower chord + 41.85, + 41.85, + 73.2, + 94.2, + 104.7; diagonals — 69.75, + 52.2, + 34.8, + 17.4, + 9.3; verticals + 9.9, — 32.1, — 18, — 4.05. Design the members that meet at the lower panel point 48 ft. from the abutment. Make, to suitable scale, detail drawings of the joint at that point.

8. If the maximum allowable pressure in pounds p per linear in. of roller is 600 d, where d is the diameter of the roller, design the expansion rollers for a city highway span 120 ft. long with roadway 18 ft. wide in the clear and sidewalk on each side 4½ ft. wide. The dead load is to be taken at 780 lb. per lin. ft. and the live load at 90 lb. per sq. ft. of roadway, including sidewalks.

(2 SHEETS) SHEET NO. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF BRIDGE DRAFTSMAN.

DIRECTIONS: Logarithm tables will be furnished by the examiner. Candidates may use the Pencoyd or Carnegie Handbooks, but no other books will be allowed. Time allowed, 8 hours.

1. Calculate the stresses in the middle panel of a through riveted Pratt truss of 133 ft. span, 20 ft. depth and 7 panels, due to a dead load of 1 000 lb. per lin. ft., and a live load of $2\frac{1}{2}$ tons concentrated at one end of the middle panel, the loads to be distributed equally between two trusses 20 ft. apart.

2. Design the lower chord and one of the vertical members for the middle panel of the Pratt truss described in question (1), showing the connections at the panel-point.

3. A Warren girder 80 ft. long is formed of equilateral triangles with sides 16 ft. long. Weights of 2, 3, 4 and 5 tons are concentrated, respectively, at the first, second, third and fourth apices along the upper chord. Determine the stresses in the diagonals due to these loads.

4. A frame in the form of an inverted queen truss is composed of a horizontal top-beam 40 ft. long, two vertical struts 3 ft. long, and three tie-rods of which the middle one is horizontal and 15 ft. long. (*a*) Find the stresses produced in the several members when a single load of 6 000 lb. is concentrated at the head of each strut. (*b*) If a wheel loaded with 12 000 lb. travels over the top-beam what members must be introduced to prevent distortion? What are the maximum stresses to which these members will be subjected?

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR THE POSITION OF BRIDGE DRAFTSMAN.

5. The platform of a bridge for a clear span of 60 ft. is carried by 2 queen trusses 15 ft. deep; the upper horizontal member of each truss is 20 ft. long; the load upon the bridge is 50 lbs. per sq. ft. of platform, which is 12 ft. wide. Find the stresses in the several members.

6. Find graphically the stresses in a pony parabolic bow-string truss of 8 panels, 80 ft. span and 10 ft. rise, (*a*) for a dead load of 1 000 lb. per lin. ft.; (*b*) the maximum and minimum stresses in the diagonals in the third panel from one end due to a concentrated load of 3 tons crossing the bridge.

7. Choose and sketch section of the end-post of a bridge to withstand a compression of 120 tons; length 28 ft., taking the unit stress from the following formula: $P = 10\,500 - 60\,\frac{l}{r}$, where l is the length of member in inches and r is the radius of gyration in inches.

8. Letter in some suitable style the title: "Design for a Steel Through Pratt Truss Highway Bridge, span 110 feet."

JUNIOR BRIDGE DRAFTSMAN.

\$900 to \$1 200.

Minimum age, 20 years. Candidates must have had some practical experience in mechanical or structural drafting. Subjects of examination and relative weights: Practical questions covering free-hand sketches of structural shapes and simple members built up of shapes, free-hand lettering, detail drawing, tracing and calculation of weights, 8; experience and education, 2. Time allowed for the written examination, 8 hours.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR JUNIOR BRIDGE DRAFTSMAN.

Time allowed, 8 hours. No books are needed, and none may be used.

1. A column 24 ft. in height is made up of four $6\frac{1}{8}$-in. Z-bars of $3\frac{5}{8}$ in. face and $\frac{7}{8}$ in. thickness, one plate 14 in. by 1 in. and four plates 20 in. by $\frac{7}{8}$ in. Draw the cross-section of the column, showing how you would build it up; also the elevation showing the rivet spacing. Calculate the weight of the column, if the metal weighs 495 lb. per cu. ft.

2. To the column described above, a beam is to be attached, composed of two 12-in. I-beams (with 5-in. flanges) and plates. Make a detail drawing of the splices and connections.

3. Make neat free-hand drawings of the standard "shapes" in which structural steel is furnished by the rolling mills, and give the proper name to each. Show five ways in which these are combined in building up beams and columns.

4. In some neat, suitable style of free-hand lettering, write the title: "Detail sheet for Through Pratt Truss for a Highway Bridge, span 80 feet."

5. A Warren girder 80 ft. long is formed of equilateral triangles, with sides 16 ft. long. Weights of 2, 3, 4 and 5 tons are concentrated, respectively, at the first, second, third and fourth apices along the upper chord. Determine the reactions of the abutments and the bending moment at the center due to these loads.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

Examination for Junior Bridge Draftsman.

6. Make plan and elevation drawings for a bridge pier 24 ft. high above the mean water surface, 32 ft. long and 6 ft. wide at the top, with a batter of 1 in. to 1 ft. on each side. The down-stream end has a batter of 1 in. to 1 ft. and is semicircular; the up-stream end is triangular and has a batter of 3 in. to 1 ft. Indicate in the drawing that the coping is to be of dressed stone, the rest of the pier to be of rough-faced stone.

7. Calculate the number of cubic yards of masonry in the pier above.

8. Make neat detail drawings of the connections at one of the upper panel points of a riveted Pratt highway truss, showing connections of post with upper chord, diagonals and lateral bracing.

9. Design a plate girder for a girder highway bridge, the girders to be 72 ft. long and $4\frac{1}{2}$ ft. deep. Show the method of building up the girder, splice plates, stiffeners, rivet-spacing, floor beam connections, etc.

10. Design the hand-railing and end-post for a railing for the sidewalk on the approach to a city highway bridge.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR JUNIOR BRIDGE DRAFTSMAN.

Time allowed for the whole examination, 8 hours. No books are needed, and none may be used.

1. In some neat, suitable style of free-hand lettering, write the title: "Design, Including Estimates and Details, for a Suburban Highway Bridge. Span 120 ft. Submitted by Wm. M. Green, C. E."

2. A through riveted Pratt highway truss has 7 panels, each 15 ft. long and 27 ft. deep. The maximum stress determined for the lower chord of the middle panel is 36 700 lb., for the lower chord of the adjacent panel 30 500 lb., for the vertical at their point of meeting 3 600 lb., for the counter of the middle panel 1 000 lb., for the diagonal of the adjacent panel 12 400 lb. The unit stress taken for tension members is 10 000 lb. and for compression members is 7 000 lb. Design from standard rolled forms the members that meet at this panel point. (Make close estimates of cross-sections that are not readily computed).

3. Calculate the weights of the bridge members you have designed in answer to the above question, if the metal weighs 492 lb. per cu. ft.

4. Make neat detail drawings showing your method of arranging and joining the above bridge members at the panel point.

(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR JUNIOR BRIDGE DRAFTSMAN.

5. Make drawings showing the details for the portal bracing for a highway bridge of the through Pratt type, span 105 ft., depth 27 ft., width between trusses 18 ft.

6. Design a timber truss for a highway span of 30 ft., showing method of its construction.

7. A plate girder is to have a span of 60 ft. and depth of 3.5 ft. The maximum required flange section is 24 sq. in. and the maximum required web section is 20 sq. in. The girder is to be designed in five panels. Make plan, elevation and section drawings, showing method of building up the girder, stiffening it, etc.

TRACER.

Minimum age, 18 years. Usual salary, $50 to $75 a month. The examination consists of practical questions and exercises in inking in drawings, making tracings and copies of drawings to scale.

SPECIMEN QUESTIONS.

1. Ink in the drawing attached.

2. Letter, in some suitable style, the following title to the drawing: "Design for a Railroad Arch Culvert."

3. Combine Figs. 1, 2 and 3 into one drawing to the scale 1 in. = 40 ft.

4. Trace Fig. 4 and ink in your tracing.

(2 SHEETS) SHEET No. 1.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR TRACER.

DIRECTIONS: Answer questions 1 to 3 on one sheet of drafting paper, questions 4 to 6 on another sheet as furnished you. Time allowed for the whole examination, 6 hours.

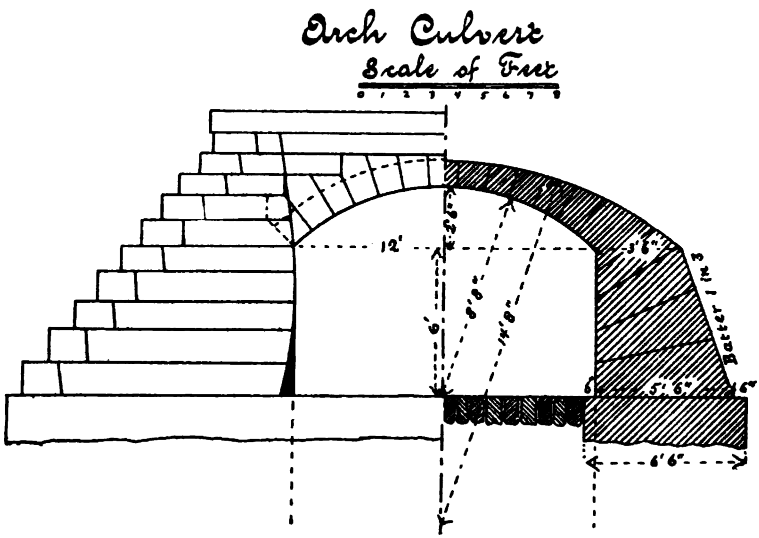
1-2. By the use of pencil, compass and straight-edge only, construct:

(*a*) A line perpendicular to a given line at its extremity.

(*b*) An arc of a circle passing through two points on a horizontal line, 2 in. apart, and a third point 1 in. above the line and to the right of the other points. Do not erase construction lines.

3. Make a perspective drawing of a cube, 2 in. high, placed below and to the left of the eye of the observer.

4-6. Copy the following drawing of an arch-culvert to the scale 1 in. equals 4 ft. and ink in your drawing.

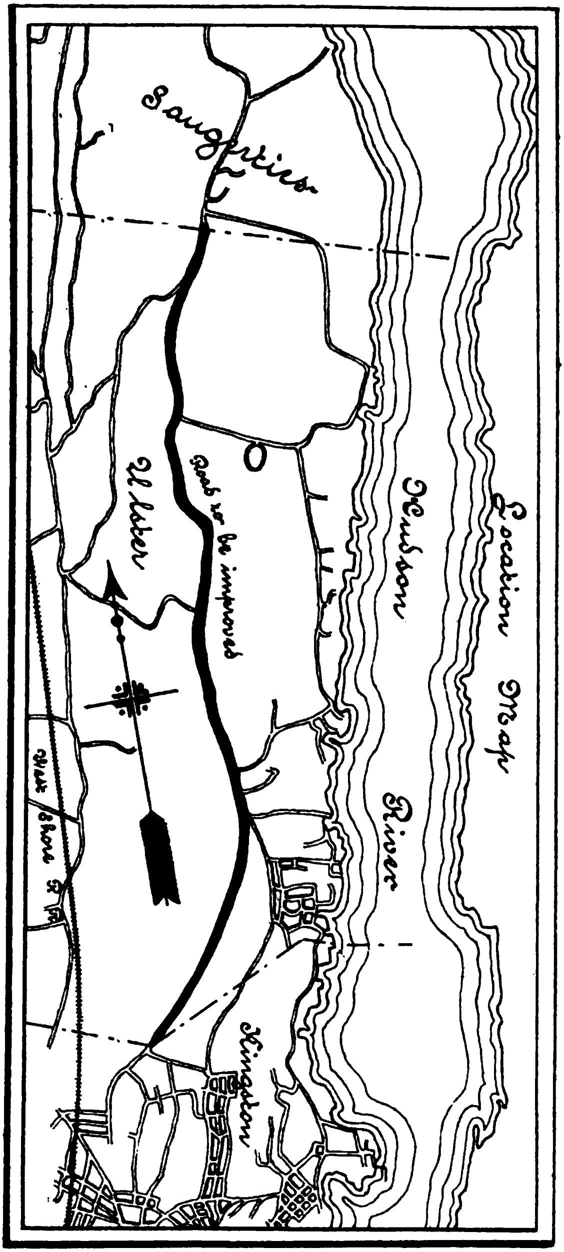


(2 SHEETS) LAST SHEET.

STATE OF NEW YORK—STATE CIVIL SERVICE COMMISSION.

EXAMINATION FOR TRACER.

7-10. On the sheet of tracing-paper furnished you, trace the map and ink it in so that blue-prints may be made from your tracing. In place of the "round-writing" used, letter your map in some other suitable style of free-hand lettering that you can do neatly and rapidly.


Location Map
Saugerties
Ulster
Road to be improved
Hudson
River
West Shore R R
Kingston

GENERAL INSPECTOR OF STREETS AND ROADS.

TECHNICAL.

1. In the selection of the kind of covering to be used for a street (whether granite block, asphalt or macadam), state the considerations or conditions that decide in each case.

2. As a rule, which do you think preferable, granite block or trap block pavement (of same shaped blocks), and why?

3. What results may there be from lack of care in preparing the ground surface for a pavement?

4. (*a*) Under what conditions should you think it necessary that a highway should be underdrained? (*b*) How should such a job be done?

5. State every defect to be looked for in the inspection of a lot of granite blocks.

6. Are defects ever found in concrete foundations for pavements, and if so, what are they?

7. State every defect to be looked for in the work of setting granite blocks; in other words, how would you inspect such a pavement?

8. In the work of refilling a trench cut for pipe-laying in a street, is it possible to do it so as to prevent all probability of settlement? If so, how should the men be distributed in the trench?

9. How would you make a quick test of cement to satisfy yourself that it is in good condition to use?

10. (*a*) In what way does wear show itself on a macadam pavement? (*b*) What are the causes of "raveling" of such pavements? (*c*) How can this largely be prevented?

11. (*a*) At what temperature should asphalt pavements be laid? (*b*) What are the results of a departure from this rule?

12. (*a*) Where (that is, in what part of a street) does water have the greatest effect upon an asphalt street surface? (*b*) Why is this the case?

13. In order to get the firmest adhesion of the asphalt to the surface below, either in new work or in making repairs, what are the essentials?

14-15. Write a complete report on the condition of three streets of considerable length which have been in use for some time, one

paved with granite blocks, one paved with asphalt, and one with macadam, giving your recommendations in each case.

INSPECTOR OF PUBLIC WORKS.

Salary, $5 per day when employed.

Open to men only. Time allowed, 6 hours. Subjects of examination and relative weights: Practical questions on materials, construction and inspection, 6; experience and personal qualifications, 4.

SPECIMEN QUESTIONS.

Practical Questions.

1. What difference should be observed between concrete construction for water-tight retaining walls and for ordinary dry foundations?

2. Name all the ways you can suggest of slighting cement masonry.

3. What are the common defects of stone and how discovered?

4. In what cases would you advise the use of grout rather than a full bed of mortar in building stonework?

5. Give the essential points in a first-class job of brickwork in cement, including materials and workmanship.

6. Describe some simple expedients to cheapen quicksand ex vation.

7. Describe the construction of the cheapest safe coffer subject to a head of 12 ft. of water and extending betwe pervious banks 100 ft. apart.

8. Describe circumstances under which wheelbarrow e is the most economical method of handling earth. Same f with shovels; handling with carts; handling with cars.

9. Suppose, in excavating for the foundations of a ment or a lock-wall, that the rock, which was thoug tically level at a certain depth, is found to fall awa a part of the foundation; what would you require of

10. Does it require more or less earth than tha ting to make an embankment of the same size? vided for in making the embankment?

11. In building a canal, suppose the bottom to be but little below the natural surface; state under this condition every precaution that should be taken or may be necessary to prevent seepage at the junction of the bank with the ground and to insure the stability of the bank.

12. Describe the materials best fitted for puddling, and how they should be used in building a bank to insure imperviousness to the passage of water.

13. What are shakes? checks? What is sapwood, and how told? What is meant by brash timber, and how told?

14. What kinds of timber last best in wet places?

15. Where round drift-bolts are to be used, as in crib-work, etc., state the requirements to be observed in boring for, driving them, etc., to get the strongest hold in the timber.

16. State all the defects you would look for in piles to be used on an important work.

17. (*a*) How would you determine that a pile has been driven to a bearing? (*b*) How would this be affected by piles brooming at the top, and what is the remedy? (*c*) Which is the most effective method of driving, by frequent blows with small fall of ram, or slow blows with a greater fall?

18. How should iron-work be prepared for repainting and what materials and method of application will give the most permanent coating?

SPECIAL EXAMINATIONS.

There are occasional special examinations for positions in which vacancies are of infrequent occurrence and for which examinations are held only when vacancies occur. As to such examinations no detailed information can ordinarily be given in advance of the advertisement of examination. For most of these positions the examination consists entirely of questions upon the duties of the position, the technical knowledge required for their performance, and the experience, education, special training and personal qualifications of candidates. A partial list of such examinations held in the past is given below. *No specimen questions for such examinations can be furnished,* nor will the subjects of examination and relative weights necessarily be the same in future examinations of similar character, as the Commission will be governed by the immediate needs of the service at the time the examinations are called.

FOREMAN OF EARTH BORINGS.

$3.50 to $5 a day.

Appointees will have charge of parties operating "Wash drills," and must have had experience in such work. Candidates are not required to appear at any place for examination, but will be rated on their experience, education and personal qualifications as shown by their sworn statements, and by the answers to inquiries made by the Commission of their former employers and others acquainted with their experience and qualifications.

FOREMAN OF ROCK BORINGS.

$3.50 to $5 a day.

Appointees will have charge of parties operating "Diamond core drills" or "Davis calyx chilled shot drills," and must have had experience in such work. Candidates are not required to appear at any place for examination, but will be rated on their experience, education and personal qualifications as above.

FOREMAN OF PUBLIC WORKS.

Open to men only. Compensation, $2.50 per day and upwards when employed. Candidates must have had thorough practical experience as foremen or in charge of men upon public works or other engineering constructions. Subjects of examination and relative weights: Practical questions on methods of construction and the employment and handling of men, 5; experience, 5.

INSPECTOR GRADE CROSSINGS BUREAU, STATE RAILROAD COMMISSION.

$1 500.

The examination relates entirely to the work of the bureau, including the laws relating thereto, methods of procedure and construction, and considerations affecting the work, and to the experience and personal qualifications of candidates.

INSPECTOR OF HIGHWAY WORK.

$3.50 to $4.50 a day when employed.

Subjects of examination and relative weights: Practical questions on materials, construction and inspection of highway work, 6; experience and personal qualifications, 4.

MECHANICAL ENGINEER AND DRAFTSMAN.

$1 500 to $1 800.

Candidates should be thoroughly familiar with the calculations and design of all kinds of shafting, gearing, chains, cables, pillow blocks, etc., especially with the design of such machinery as is used on swing and lift bridges, mechanical locks, etc. Candidates must have at least five years' practical experience in drafting, designing and constructing this class of work. Subjects of examination and relative weights: Practical and theoretical questions on proportioning machinery as above outlined, 6; experience, education and personal qualifications, 4. For part of the examination candidates may use tables and books of reference as desired.

RESIDENT ENGINEER.

$2 400 a year.

Applicants must have had at least five years' practical experience in civil engineering work, three years of which must have been in responsible charge of work. Candidates will not be required to appear at any place for examination. Subjects of examination and relative weights: Experience, education and personal qualifications rated upon the candidate's detailed statements and upon the answers to inquiries by the Commission from their previous employers and superiors, 5; two theses—a report upon some work of importance carried out under the charge of the candidate, and a discussion of some assigned topic relating to the problems to be handled in the construction of the proposed barge canal in this state, 5. The theses are to be written and submitted by the candidate in accordance with specifications and instructions issued by the Commission.

CIVIL SERVICE OF THE CITY OF BUFFALO.

INSTRUCTIONS TO APPLICANTS.

1. All applications by those desiring to render services, within schedule "B," except in Police and Fire Departments, of the rules and regulations prescribed for entering the Civil Service of the City of Buffalo, must be addressed to the "Secretary of the Buffalo Civil Service Commission, Buffalo, N. Y."

2. All such applications must be made under oath, and must state the following facts:

That the applicant is above the age of 21 years, and under 60 years of age; that he is a citizen of the United States and has resided *continuously in Buffalo for the last three years preceding his application;* the street and number of his residence and his post-office address; his age, date and place of birth; the nature of his education; his business training and experience, and his business or employment and residence for the last previous five years; whether he has ever been in official service before, and if so, when and where; and whether he has ever been discharged therefrom, and if so, the reason therefor; whether he has been honorably discharged from military or naval service of the United States, as soldier, sailor or marine during the late Civil War, in which case the discharge, or a duly authenticated copy thereof, shall be submitted with the application; that he is free from any disease or physical defect which might impair his ability to render good and faithful service to the City of Buffalo.

3. The application must contain the certificates of not less than three and not more than five reputable citizens of Buffalo that they, individually, have been personally acquainted with the applicant for at least one year and believe him to be of good moral character, of temperate and industrious habits, and in all respects fit for the service he wishes to enter, and that each such citizen is willing to answer such detailed questions as may be addressed to him by the Commission in relation thereto, and that such certificate should be published for public information.

The applicant should also state whether the application is limited to any particular office or offices in the service. All applications must be in handwriting of applicant.

4. No recommendations or certificates besides those provided for on the blanks will be received, and no additional recommendations can be of any use in securing an appointment.

5. The applicant will be notified of the first examination which he may attend after his application is received. He should give notice of any change of residence.

6. A failure to properly fill the blanks, or to send satisfactory certificates, will cause the application paper to be returned for correction. Applications showing that the applicant lacks the qualifications as to age, health, etc., will be rejected.

7. Applicants may be notified of the result of examinations; when appointed they will be notified of their appointment by the appointing officer.

8. Priority of the date in examination will give no advantage; appointments are made from those standing highest on the eligible list in the order of their standing.

9. No person whose general average standing is less than 75 will be entered on the eligible list.

10. Each subject is marked upon a scale of 100, which represents the maximum possible attainment.

11. Every false statement knowingly made by any person in his application for examination, and every connivance by him at any false statement made in any certificate which may accompany his application, or wilful complicity in any fraud designed to improve his standing upon examination, any physical disability of the applicant which would render him unfit to perform the duties of the position to which he seeks appointment; his being addicted to the habitual use of intoxicating beverages to excess, or his being guilty of a crime, or infamous or notoriously disgraceful conduct, shall be good cause for refusing such person any examination or any rating upon an examination, or for striking his name from any eligible list, or for the removal of such person from any position to which he may have been appointed.

All appointments are first made for a probationary term of three months; if not permanently appointed then, the applicant shall be ineligible for re-examination for one year.

12. No one dismissed from the service for misconduct can be reexamined for appointment in any capacity in the service within two years from such dismissal.

ENGINEERING STAFF IN THE CITY OF BUFFALO, N. Y.

1 Deputy Engineer Commissioner......	Salary	$3 000	per	annum.
1 Assistant Engineer	"	2 500	"	"
2 Assistant Engineers	"	2 400	"	"
3 " "	"	1 800	"	"
1 Assistant Engineer	"	1 600	"	"
1 " " in charge of street repairs	"	1 500	"	"
8 Transitmen	"	1 200	"	"
12 Rodmen	"	900	"	"
2 Draftsmen	"	1 100	"	"

EXAMINATION FOR ASSISTANT CITY ENGINEER.

EXPERIENCE SHEET.

MARCH 11TH, 1905.

NOTE.—It is desired that applicants should write freely and fully in answer to the following questions, as great importance will be attached to both technical and practical experience, as shown by this part of the examination.

1. What preparatory school have you attended and how long?

2. Have you completed a course in engineering at a correspondence school?

3. (*a*) What college or technical course did you pursue? (*b*) When and where? (*c*) Did you complete the entire course, and have you a diploma from that institution? (*d*) If so, what degree does it confer?

4. (*a*) Have you ever been in City, State or National employ? (*b*) If so, in what capacity, and on what work?

5. Write a full and complete account of your other engineering employment. Describe the work to which you were assigned, stating your special duties and responsibilities.

NOTE.—This question is framed with the intention of bringing out the applicant's engineering experience since leaving school or college, *and as it is desired to give full credit for practical accomplishments the applicant will do well to write a full and accurate account of his engineering work.* It is suggested for his assistance, that he begin with his first practical experience, and follow on, year by year, with a narrative of his activities, giving some idea of the magnitude and values of the work in which he has been engaged.

EXAMINATION OF ASSISTANT ENGINEERS.

TECHNICAL SHEET No. 1.

1. (*a*) Make a complete cross-section of an asphalt pavement giving dimensions. (*b*) Draw specifications covering excavation (the excavation to be in earth). (*c*) Draw specifications covering the curbing and the setting and draining of the same. (*d*) Draw specifications covering the foundation course. (*e*) Draw specifications covering the spreading and finishing of the asphalt.

2. Make sketch and describe briefly how you would construct a pile foundation for bridge pier where it is necessary to go through 15 ft. of quicksand to reach a solid clay bottom.

3. How would you measure the flow of water over a weir?

EXAMINATION FOR ASSISTANT ENGINEERS.

TECHNICAL SHEET No. 2.

4. In a stand-pipe 110 ft. high, filled to within 15 ft. $10\frac{1}{2}$ in. from the top, what is the pressure, in pounds, at the base?

5. (*a*) Design a 4-ft. brick sewer. In your design show a cross-section, with a house connection. Also a manhole showing the sewer passing through it. (*b*) State briefly the essential things to be looked out for in the construction of your sewer. (*c*) Your sewer is 4 000 ft. long and averages 12 ft. below the surface, and rock excavation begins 300 ft. from one end and is 7 ft. thick at the other end. Space your manholes 500 ft. apart with one at each end. Make a preliminary estimate of cost, including manholes, but not including any house connections.

EXAMINATION FOR TRANSITMAN.

HELD APRIL 8TH, 1905.

1. A pier is 4 by 15 ft. on the base and 16 ft. high, and has a batter of $\frac{1}{2}$ in. to the foot. Find the number of cu. yds. of masonry, the total weight, at 150 lb. per cu. ft., and the pressure per square foot on the base.

2. Make up a typical transit-book page, notes to show one angle in the center line, two cross-streets, curb lines, a flat, store, residence with iron fence, a stone monument, double-track trolley line in one of the intersecting streets.

3. Lay out a $1\frac{1}{2}°$ curve with a deflection angle of 4° 27′, the plus of your P. C. being 16 + 71.4.

4. If you were called upon to run in 400 ft. of sewer grade, how would you do it with a transit that did not have an attached level?

5. You want to take soundings in Niagara River, using a base line on shore. How would you arrange your instruments on shore? Give method of procedure.

6. A plot of ground is 600 ft. square and has an interior point 11 ft. higher than the elevations at the corners, which elevations are the same. How would you make a contour survey of it for a topographical map?

7. Make plot of map showing necessary elevations and plot 2-ft. contours.

8. Starting from a bench, elevation of which is 756.73, your rod reads 1.42 and rods on center-line stations are 0.78, 3.41, 7.03, 9.56,

11.87 and on a T. P. 12.12. On new set-up they are on T. P. 2.31 and on new stations 3.01, 4.55, 0.77, 9.13 and 12.97. You have a 2% down grade with grade elevation at Station 1 of 748.16. Make a page of level notes, giving cuts and fills at stations.

EXAMINATION FOR RODMAN.

Experience Sheet.

Note.—It is desired that applicants should write freely and fully in answer to the following questions, as great importance will be attached to both technical and practical experience, as shown by this part of the examination.

1. What schools have you attended and for what period of time?

2. (*a*) What college or technical course did you pursue? (*b*) When and where? (*c*) Did you complete the entire course, and have you a diploma for that institution? (*d*) If so, what degree does it confer?

3. (*a*) Have you ever been in City, State or National employ? (*b*) If so, in what capacity, and on what work?

4. Write a full and complete account of your other engineering employment. Describe the work to which you were assigned, stating your special duties and responsibilities.

This question is framed with the intention of bringing out the applicant's engineering experience since leaving school or college, and as it is desired to give full credit for practical accomplishments the applicant will do well to write a full and accurate account of his engineering work. It is suggested for his assistance that he begin with his first practical experience, and follow on, year by year, with a narrative of his activities, giving some idea of the magnitude and values of the work in which he has been engaged.

EXAMINATION FOR CHAINMAN.

Technical Sheet.

1. How long is a Gunter's chain?

2. Explain the use of eleven pins.

3. Explain how you would chain on a slope steep enough to make it necessary to break chain.

4. Describe the method of locating a point by intersections.

5. How would you lay out a right angle with a chain?

6. In using a steel tape, 100 ft. long, with the last foot graduated in tenths, describe how the two chainmen would determine

and read the plus of a station several hundred feet from the starting point.

7. State the proper way to hold the flag or transit rod.

8. If you were sent out to measure up the finished portion of work on a paving contract, how would you do it if the street were hilly?

9. Describe the method of making a chain survey of a six-sided field.

10. A house stands on the line in a chain survey, how would you chain past it?

11. On account of a rise of ground neither end of a line is visible from the other. Describe the first thing to be done in order to get the measurement.

12. A reservoir site has two parallel sides, and two right angles. (*a*) Describe how you would make a complete chain survey. (*b*) How would you calculate the area?

13. A rectangular city block contains 2.324 acres and is twice as long as it is wide. Give the dimensions.

14. How many square feet of land are there in a street 4 rods wide and 1¾ miles long?

15. How many cubic yards of sand under a stone pavement, 30 ft. wide and 2 740 ft. long, the sand being 14 in. deep?

EXAMINATION FOR ROD AND AXEMEN.

HELD JUNE 23D, 1904.

1. What is the length of a Gunter's chain?

2. If a tape is divided into feet and tenths, how many tenths will there be in 48½ ft.?

3. Reduce 262° 44′ 18″ to seconds.

4. Find the capacity in cubic feet of a box of which the inner dimensions are: Length, 25 in.; breadth, 17 in., and depth, 11½ in.

5. What is a transit line?

6. What is land surveying?

7. State in a general way the use of a level.

8. State in a general way the use of a leveling rod.

9. What is a bench-mark?

CIVIL SERVICE OF THE STATE OF MASSACHUSETTS AND THE CITY OF BOSTON.

Instructions to Applicants and Eligibles.

A person desiring to be examined for a position in the classified service should file an application on the prescribed blank, and a form for that purpose can be obtained at the office of the commissioners, room 152, State House, Boston, or of the secretary of the local board of examiners in the city where he lives.

Applications for the service of the Commonwealth and of the city of Boston should be filed in the commissioners' office, Boston; if for service in any city other than Boston they should be filed with the secretary of the board of civil service examiners in such city.

Applications will be received at any time, and notice of the time and place of examination will be seasonably sent to each applicant. If unable to attend the first examination after applying, the applicant will, upon satisfactory explanation, be notified to attend the next examination.

Non-competitive examinations are not given when it is practicable to establish an eligible list by competition, and they are never held at the request of an applicant.

The commissioners cannot furnish information as to the course of preparation which applicants should follow (except as shown by the specimen examination papers printed in their report), nor can they answer inquiries in relation to cases which are not before them for decision, or decide, except in the cases of actual applicants, questions respecting the application of the rules. Particular answers cannot be given to inquiries which are answered herein, directly or by implication.

Notice will be sent by mail to each examined applicant of the result of his examination as soon after the examination as it is practicable to do so.

The names of persons who have passed the required examination will remain on the eligible list two years from the date of their certificate, unless dropped therefrom after certification three times, or removed from said list for cause.

Applicants for clerical service whose names have been placed on the eligible list in Class 2 of Schedule A may also, *upon request in writing,* have their names placed on the eligible list for positions in Class 1 of Schedule A, with the same standing.

Applicants for clerical service in the departments of the Commonwealth whose names have been placed on the eligible list may, *upon request in writing,* have their papers marked by the local board of examiners of the city in which they reside, and their names placed on the eligible list for service in the departments of such city, and *vice versa.*

Persons whose names have been placed on the eligible list in Class 1 of Schedule B (prison service), and who have been certified for appointment, will be subjected to a physical examination if the appointing officer so requests.

The relative standing of any applicant as compared with that of others on the same eligible list may be changed by the addition of names of persons who have obtained higher standing at some more recent examination, and the time of the examination is not considered in making certifications.

Eligibles are certified in the order of their grade, and nothing can help and nothing can hinder their certification for appointment in the order of eligibility as prescribed by the civil service rules.

The commissioners are unable to answer inquiries as to vacancies in the service, salaries, prospects of certification, appointment or promotion. They know nothing of vacancies until requested to certify names for filling them, and it can only be generally said that the highest mark possible is 100, the lowest which gives eligibility is 65, and that the nearer the applicant's mark is to 100 the more likely it is that his name will be reached for certification. It is wholly uncertain, therefore, when an applicant's name may be reached for certification, and it is useless to speculate on what his chances may be.

Applicants will save the commissioners and themselves time and trouble by carefully reading the foregoing and preserving it for reference.

DIVISIONS OF THE CIVIL ENGINEERING FORCE.

Division A, or rodmen: To include chainmen, rodmen, and all assistants under whatever designation, except draftsmen, whose maximum pay does not exceed the rate of $800 per annum.

Division B, or instrument men: To include transitmen, levellers and all assistants under whatever designation, except those covered by divisions A and E, and whose maximum pay does not exceed the rate of $1 100 per annum.

Division C, or assistant engineers (junior grade): To include engineers and surveyors in responsible charge of work and engineers in charge of designing whose maximum pay does not exceed the rate of $1 600 per annum.

Division D, or assistant engineers: To include all engineers whose pay exceeds the rate of $1 600 per annum.

Division E,* or draftsmen (junior grade): To include all assistants whose duties are chiefly those of drafting and whose rate of pay does not exceed $800 per annum.

Division F, or draftsmen (senior grade): To include all assistants whose duties are chiefly those of drafting and whose pay is at the rate of over $800 and does not exceed $1 300 per annum.

SCHEDULE B, CLASS 12, DIVISION A* (RODMAN).

Handwriting; shown by copying printed matter.

Spelling; twenty words, announced by one of the examiners.

Education and experience.

The answers to the questions on this sheet will be marked under the heads of Education and Experience. *Any false statement made by the applicant in answering these questions will be regarded as good cause for excluding him from the eligible list, or for removal or discharge during probation or thereafter.*

What is the date of your birth?

State what grammar school, high school, technical school or college you have attended, the dates and length of attendance, the studies pursued and diplomas taken. State any other facts regarding your education which you think may be of service to the examiners.

Have you had any practical experience in the duties of the position for which you apply? If you have, state the particular position or positions you have held; the nature of your duties in each case; where, when, how long and under whom (giving accurately the name and address) you have been so employed.

Are you employed at present? If you are, give the name and address of your employer, state the nature of your duties and the length of time you have held this position. If you are not employed, state how long you have been without employment and the cause for which you last ceased work.

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* The examination for division A and for division E will occupy one day each. The examinations for the other divisions will occupy two days each.

PREVIOUS EXAMINATION PAPERS.

RODMAN.

ARITHMETIC.

Including common and decimal fractions, percentage, square root, mensuration of rectangular surfaces and solids.

SAMPLE QUESTIONS.

1. Add 467 ft. $8\frac{1}{2}$ in., 27 ft. $9\frac{7}{8}$ in., 510 ft. $4\frac{1}{8}$ in., and 102 ft. $6\frac{5}{8}$ in., and from the sum subtract 299.52 ft., giving the answer to the nearest eighth of an inch.

2. Multiply two hundred fifty-seven ten-thousandths by forty-nine thousandths.

3. Divide 2 880 by .0036.

4. Add $\frac{10}{11}$, $\frac{128}{125}$ and $\frac{58}{55}$, and reduce the sum to a decimal fraction carried to five places of decimals.

5. A dry brick weighing 4 lb. 6 oz. was immersed in water for twenty-four hours, at the end of which time it was found to weigh 5 lb. $0\frac{1}{2}$ oz.; what per cent. of its own weight was absorbed?

6. A square plot of ground contains 108 900 sq. ft.; what is the length of a side?

7. A rectangular piece of land, 210 ft. 3 in. long and 50 ft. 9 in. wide, has a ditch 6 ft. wide and 4 ft. deep, which was dug inside the boundary lines, said lines being the outer edge of the ditch. How many cubic yards of material were removed from the ditch?

ALGEBRA.

To and including the solution of simultaneous equations of the second degree.

SAMPLE QUESTIONS.

1. Multiply $\left(x^2 - \frac{x}{3} + \frac{1}{4}\right)$ by $\left(\frac{x}{2} + \frac{1}{4}\right)$.

2. Divide $256\, a^3\, b\, c^2\, x^3$ by $-\, 16\, a^2\, c\, x^2$.

3. Divide a distance of 1 000 ft. into three parts—A, B and C—such that A shall be 72 ft. longer than B and 100 ft. shorter than C. Solve by algebraic method.

4. Solve the equation $2\sqrt{x} + \frac{2}{\sqrt{x}} = 5$.

5. A rectangular field contains 40 960 sq. ft. If its length were increased by 65 ft. and its breadth by 50 ft., its area would be increased by 26 450 sq. ft. Find the length and breadth of the field.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. One interior angle of a certain triangle contains 43° 19′ 40″; a second interior angle contains 105° 59′ 20″; what is the value of the remaining angle?

2. Choose any three points on paper, and by aid of a sketch explain how, by geometrical construction, you would find the center of a circle passing through them.

3. What is the length of the circumference of a circle which would enclose an area of 5 000 sq. ft.? $\pi = 3.1416$.

4. If a field have two parallel sides, one of them 356 ft. long and the other 407 ft. long, the perpendicular distance between them being 96.5 ft., what is the area of the field?

5. A stone in the form of a pyramid 3 ft. high, with its base a square 30 in. on a side, will weigh how much, assuming 150 lb. weight to the cubic foot?

Duties.

Questions relating to the construction and use of rods, tapes, verniers and other implements and devices. Details of the work of rodmen in the field and office. Definitions of technical terms.

Tracing.

Tracing-cloth and a plan or a drawing of some engineering structure are furnished the applicant, who will be required to make a tracing in India ink.

SCHEDULE B, CLASS 12, DIVISION B (INSTRUMENT-MAN).

Handwriting.
Spelling.
Education and experience.
} Same as Division A.

ALGEBRA.

To and including the solution of simultaneous equations of the second degree.

SAMPLE QUESTIONS.

1. Simplify, as far as possible, the expression $\dfrac{x - 1 - \dfrac{12}{x+3}}{x - 5 + \dfrac{12}{x+3}}$

2. Solve the equation $\left(\frac{a}{b} + \frac{b}{a}\right)x - \left(\frac{a}{b} - \frac{b}{a}\right) + 2x = a.$

3. The circumference of the hind-wheel of a carriage is greater by 4 ft. than that of the fore-wheel. In traveling 1 200 yd., the fore-wheel makes 75 revolutions more than the hind-wheel. Find the circumference of each wheel.

4. A man has two square lots of unequal size, together containing 15 025 sq. ft. If the lots were contiguous, it would require 530 ft. of fence to embrace them in a single enclosure of six sides. Find the area of each lot.

5. Solve, for either x or y, the simultaneous equations: $\begin{cases} x^2 + 3y^2 = 28 \\ x^2 + 2y^2 + xy = 16. \end{cases}$

GEOMETRY.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

SAMPLE QUESTIONS.

1. The altitudes of two equilateral triangles are respectively as 3 to 4. Find the ratio of their areas, and give your reasoning.

2. Show how, by geometrical construction, you would divide a given straight line into any required number of equal parts. Give the reasoning upon which you base your construction.

3. Find the length of the perimeter of an equilateral triangle which would enclose one acre.

4. A metal cylinder 5 ft. long and 8 in. in diameter is turned down in a lathe to a diameter of 6 in. Find the total weight of metal removed, assuming 450 lb. per cu. ft.

5. A cone measures 32 ft. around the base, and the length of its slope is 8 ft. Find the number of cubic yards it contains.

Trigonometry.

Plane trigonometry,—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. What do you understand by the cosine of an angle? By the tangent? By the versed sine? The sine of a certain angle is $\frac{1}{3}$; compute its cosine. What is the cosine of 135°?

2. What do you understand by the base of a system of logarithms? What is the base of the common system? In the common system, what is the logarithm of 1? Of 1 000? Of 0.01?

3. Compute by logarithms:

$$\frac{3.7096 \times 286.51 \times 0.2956}{1633.72};\ (23.8464)^3;\ \sqrt[3]{0.0042937}.$$

4. In a right-angled triangle the hypothenuse measures 154 ft., and one of the acute angles 49° 53′. Compute, by natural functions, the lengths of the sides; determine also the area of the triangle.

5. In an oblique triangle, the angle B measures 19° 21′ 40″, the angle A 103° 35′, and the side opposite B 87.36 ft. Compute, by logarithms, one of the remaining sides.

Duties.

Questions relating to the details of the work of the second man in a surveying party, in the field and office, including the construction, adjustment, care and use of the transit and level; compass and stadia surveying; details of surveying and leveling, keeping field notes, measuring and counting earth work. Definition of technical terms.

Plotting.

Plotting a survey by co-ordinates from field notes, inking-in plot and lettering a title.

Sample Question.

Plot accurately on a scale of 20 ft. to an inch, the survey of a lot of land given in the following notes:

Station.	Bearing.	Distance.
1.	N. 35° 0′ E.	108.00 feet.
2.	N. 83° 30′ E.	51.60 "
3.	S. 57° 0′ E.	88.80 "
4.	S. 34° 15′ W.	142.00 "
5.	S. 56° 30′ W.	129.20 "

Ink in the plot, mark the bearing and length of each side, and letter the following title, making your own arrangement: "Plan of land belonging to John Smith, December, 1897. Scale, 20 ft. to an inch." (Arrange and space all letters, and finish enough in each line to show your skill.)

SCHEDULE B, CLASS 12, DIVISION C (ASSISTANT ENGINEER, JUNIOR GRADE).

Education and Experience.

Same as Division A.

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Find, in as simple form as possible, the value of

$$\left(\frac{2}{3\,y^2} - \frac{2}{x\,y} + \frac{3}{2\,x^2}\right) \div \left(\frac{2}{3\,y^2} - \frac{3}{2\,x^2}\right)$$

2. Increase the length of a given rectangle 2 ft., and its width 1 ft., and its area is increased 12 sq. ft. On the other hand, diminish its length 3 ft., and its width 2 ft., and its area is diminished 11 sq. ft. What is the perimeter of the rectangle?

3. Francis' formula for the discharge over suppressed weirs is $Q = 3.33\,l\,h^{\frac{3}{2}}$, in which, if l and h are in feet, Q is in cubic feet per sec. If h be 0.324 ft., what value of l will correspond to 5.37 cu. ft. per second for Q?

4. A boat's crew rowed down stream 7 miles and back in 3 hours 20 minutes. The velocity of the current was 2 miles per hour. How many miles per hour would the crew make in still water?

5. Two loans, together amounting to $45 000, are made at different rates of interest, but the amounts borrowed are such that the respective annual interest payments are equal. If the first loan were to be charged the second's rate of interest, its annual payment would be $800; and if the second loan were to be charged the first's rate of interest, its annual payment would be $1 250. Find the respective rates of interest.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas, and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. Explain, by reference to a sketch, how you would divide a line that is 26 in. long into three parts proportional to the numbers $2, \frac{3}{4}, \frac{1}{2}$. Compute also the lengths of the respective parts.

2. A hexagonal bar of steel, 10 ft. 3 in. long, measures 12 in. around the perimeter of a right section. What is the weight of the bar, at 490 lb. per cu. ft.?

3. A trapezoidal lot of land, 120 ft. in length, measured perpendicularly between its parallel ends, tapers uniformly and equally on both sides from a width of 24 ft. at one end to 14 ft. at the other end. Where should it be cut transversely, that is, parallel to the ends, so as to make two pieces of equal area?

4. The base of a pyramid contains 144 sq. ft. A plane parallel to the base and 4 ft. from the vertex cuts a section containing 64 sq. ft. What is the height of the pyramid?

5. A hollow cylinder 4 ft. in diameter and 15 ft. long, lying upon its side, is filled with water until the latter touches two-thirds of the circumference, at which time it is also within 1 ft. of the top. How much water does the cylinder then contain?

Trigonometry.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. The value of the sine of a certain angle is $\frac{12}{13}$. Without using tables, find the value of cosine, tangent, cotangent, secant and cosecant, and show clearly your method.

2. Three times the sine of a certain angle is equal to twice the square of the cosine of the same angle. What is the angle?

3. By logarithms obtain the value of the following expression:

$$\frac{(0.68291)^{\frac{5}{2}} \times \sqrt{5.9546} \times \sqrt[3]{61.2}}{\sqrt[5]{298.543}}$$

4. Two tangents to a circular curve of 3 000 ft. radius intersect so as to include an interior angle of 157° 8′. Find the length of either tangent from point of contact with curve to point of intersection, using natural functions.

5. A distance $A\ B$ across a stream is to be determined. A base line $A\ C$, 200 ft. long, is measured off on one bank, sights are taken from each end of it to B, and the angles which the lines of sight make with the base are measured, A being 104° 53′ and C 58° 11′. Compute the distance $A\ B$, using logarithms.

Duties.

Questions relating to the work of the head of an engineering field party, including the special work of surveying in cities, giving lines and grades for construction, measuring and estimating earth, rock and quantities in engineering structures; definition of technical terms; surveying problems.

Engineering Theory.

Elementary principles of mechanics, hydrostatics and hydraulics, and their application to simple problems. Problems in surveying.

Sample Questions.

(Applicants are required to answer but three questions.)

1. The notes of a survey and the calculated latitudes and departures are as follows:

Stations.	Bearings.	Distances.	Latitudes.	Departures.
1.	N. 30° 0′ E.	328.68	284.64	164.34
2.	N. 57° 45′ E.	306.90	163.78	259.54
3.	S. 39° 30′ E.	396.00	305.58	251.87
4.	S. 37° 15′ W.	391.38	311.53	236.92
5.	N. 69° 15′ W.	465.96	165.07	435.78

Balance the survey, give the error of closure and calculate the area.

2. Two streets intersect at an angle of 42° 28′. It is desired to ease the acute-angled intersection, making the street boundary a circular curve of 10-ft. radius, tangent to the street lines. Give the area of the land to be taken, and the length of each line bounding it.

3. What should be the cross-section of a yellow pine beam 12 ft. long, supported at both ends, to sustain with safety a center load of 5 000 lb.?

What should be the cross-section if the load is uniformly distributed?

If a beam of the same length is fixed at one end only, and has the same load concentrated at the other, what should be the cross-section?

Assume for all cases an extreme fiber strain of 1 250 lb. per sq. in. The moment of inertia of a rectangle is $\frac{b\,h^3}{12}$.

4. Compute the number of square yards of paving in the roadbed of a section of a curved street 30 ft. wide, the radius of the center line being 175 ft. and the angle at the center being 47°.

5. A rectangular wall 10 ft. high, weighing 140 lb. per cu. ft., would need to be how thick in order to be stable against overturning, if exposed to the pressure of water standing level with its top on one side only?

6. Compute the tension in pounds per square inch in the metal of a water pipe, if the metal be ½ in. thick, the inside diameter of pipe 2 ft., and the water pressure that due to a static head of 207 ft.

7. The diameter of a steam engine cylinder is 9 in., the length of crank 10 in., the number of revolutions per minute 110, and the mean effective pressure of the steam 35 lb. per sq. in. Find the indicated horse-power.

Materials and Methods of Construction.

Properties and characteristics of the various materials used in engineering construction; proper tests to be applied to ascertain their strength and other qualities; methods employed in preparing and placing the materials in the work; definition of technical terms.

The questions which have been given have related to stone and brick masonry, methods of laying and bonding various classes of masonry, and the qualities of the several materials entering into their construction; to the different kinds of hydraulic cements, their strengths and methods of testing; to concrete, the proper proportions of the several ingredients and methods of mixing and depositing under different conditions; to the different kinds of roads and pavements, the materials used and methods of building; to the properties and characteristics of cast iron, wrought iron and steel, to the uses for which each is best adapted, and to their strengths and methods of testing the same. Definition of technical terms in common use in engineering specifications.

SCHEDULE B, CLASS 12, DIVISION D (ASSISTANT ENGINEER, SENIOR GRADE).

EDUCATION AND EXPERIENCE.

Same as Division A.

TRIGONOMETRY.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

SAMPLE QUESTIONS.

1. The value of the tangent of a certain angle is $\frac{5}{12}$. Without using tables, find the value of sine, cosine, cotangent, secant and cosecant, and show clearly your method.

2. Water runs 42 in. deep in a 48-in. circular conduit. What is the area of the water section?

3. By logarithms obtain the value of the following expression:

$$\frac{(0.68291)^{\frac{3}{2}} \times \sqrt{5.9548} \times \sqrt[3]{61.2}}{\sqrt[5]{288.543}}.$$

4. Two tangents to a circular curve of 2 900 ft. radius intersect so as to include an interior angle of 157° 8′. Find the length of either tangent from point of contact with curve to point of intersection, using natural functions.

5. A distance *A B* across a stream is to be determined. A base line *A C*, 220 ft. long, is measured off on one bank, sights are taken from each end of it to *B*, and the angles which the lines of sight make with the base are measured, *A* being 104° 53′ and *C* 58° 11′. Compute the distance, *A B*, using logarithms.

ENGINEERING THEORY.

Same as Division C.

MATERIALS AND METHODS OF CONSTRUCTION.

Same as Division C (*except for surveyors**).

* For surveyors (instead of materials and methods of construction): Advanced surveying. Questions in geodetic, topographic and hydrographic surveying, methods of accurate land surveying and leveling in cities; details of the work of laying out and grading new streets and relocating old streets; evidence of ownership in disputed boundary lines. Surveying problems.

Designing.

This subject requires the applicant to make a complete design of an engineering structure in the particular line of work in which he is engaged, or in which he seeks employment, and to answer pertinent questions as to the actual work of construction. Data to the extent usually available in actual practice will be given, and from these the applicant must make the necessary computations, prepare plans and sketches, showing clearly his design, and write a brief specification of the work to be done, the whole to be in sufficient detail to enable a definite proposal to be made for building the proposed structure.

At the beginning of his second day's work each applicant has been required to announce his choice of some one of the following optional subjects upon which he elected to be examined:

1. Design for a plate-girder bridge.

2. Design for a through-truss highway bridge.

3. Design for a bridge abutment of masonry, with wing walls.

4. Design for a street intersection.

5. Advanced surveying, and surveying problems.

6. Design for the cross-section of a trunk sewer.

7. Design for a system of separate sewers.

8. Questions relating mainly to excavation and embankment; heavy masonry construction in tunnels, aqueducts and walls; water-pipe laying; and the interpretation of drawings. A certain amount of choice has been permitted in the subdivisions of this class.

SCHEDULE B, CLASS 12, DIVISION E (DRAFTSMAN, JUNIOR GRADE).

Handwriting. Spelling. Education. Experience. Arithmetic. Algebra. Geometry. Tracing.	Same as Division A.

Instead of the subject called "Duties," which appears in the rodman's examination, the applicants for this division will be given elementary drawing.

SCHEDULE B, CLASS 12, DIVISION F (DRAFTSMAN, SENIOR GRADE).

Handwriting. Spelling. Education and Experience.	Same as Division A.

Arithmetic.

Including common and decimal fractions, percentage, square root, mensuration of rectangular surfaces and solids.

Sample Questions.

1. Change the following lengths to feet and inches, giving the answers to the nearest eighth of an inch: 12.56 ft.; 6.82 ft.; 4.20 ft.

2. Divide one and six hundred sixteen thousandths by eight ten-thousandths.

3. Add $\frac{11}{14}$, $\frac{3}{10}$ and $\frac{19}{21}$, and from the sum subtract nine thousand one hundred forty-seven hundred-thousandths. *Carry the work to five places of decimals.*

4. Twenty-five thousand ft., board measure, of 2-in. plank were sent from the lumber yard to cover the roadway of a bridge 260 ft. long and 42 ft. wide. What per cent. of the planking was wasted?

Algebra.

To and including the solution of simultaneous equations of the second degree.

Sample Questions.

1. Multiply $\frac{10\ a^3\ y}{9\ bx^2}$ by $\frac{3\ b^4\ x^3}{4\ a^3\ y^2}$.

2. Divide $x^6 - 6\ x^4 + 5\ x^2 - 1$ by $x^3 + 2\ x^2 - x - 1$.

3. There are three numbers. If we add $\frac{1}{2}$ the first to $\frac{1}{3}$ the second plus $\frac{1}{4}$ the third, the sum will be 62. Or $\frac{1}{3}$ the first plus $\frac{1}{4}$ the second plus $\frac{1}{5}$ the third equals 47. Or $\frac{1}{4}$ the first plus $\frac{1}{5}$ the second plus $\frac{1}{6}$ the third equals 38. Find the numbers.

4. Solve the equation $4\ x - \frac{14 - x}{x + 1} = 14$.

5. A rectangular plot of ground is surrounded by a walk 7 ft. wide. The area of the plot and walk is 15 000 sq. ft., and of the walk 3 696 sq. ft. Find the length and breadth of the plot.

Geometry.

The applicant will be expected to have such familiarity with the principal theorems of plane and solid geometry as will enable him to solve simple problems dealing with lines, angles, areas and volumes. *Demonstrations of theorems will not be required.*

Sample Questions.

1. Through the vertex of a right angle a straight line of indefinite length is drawn, lying outside the angle. What is the sum of the two acute angles thereby formed? *Give your reasoning.*

2. If the angle at the vertex of an isosceles triangle is a right angle, what ratio exists between the base and the altitude? *Give your reasoning.*

3. Supposing a tangent drawn to a circle from a given point without; show by a sketch how you would determine the precise point of tangency. *Give the reasons for your method.*

4. The bases of a trapezoid are 32 ft. and 20 ft. respectively. Each of the other sides is 10 ft. Find the area of the trapezoid.

5. A cubic foot of brass is drawn into a wire $\frac{1}{8}$ inch in diameter. Find the length of the wire to the nearest foot. $\pi = 3.1416$.

Trigonometry.

Plane trigonometry—trigonometrical functions, properties of logarithms and use of logarithmic table, solution of triangles, either right or oblique, by either natural functions or logarithms.

Sample Questions.

1. In a triangle $A\ B\ C$ the angle A is 90°; the side $A\ B$ is 4 units long, $A\ C$ 3 units, and $B\ C$ 5 units. State, from inspection of the figure, the value of the cosine of the angle C; the sine of B; the tangent of C; the secant of B.

2. Construct on paper an angle of 53° 14′ by means of its tangent (to be obtained from the tables), and explain your method.

3. Multiply 4978.3 by $(0.2916)^3$ and divide the result by $\sqrt[5]{1.985}$, using logarithms for all the computations.

4. A regular octagon is inscribed in a circle of 8 ft. diameter. Compute the length of a side, using only natural functions for the angles.

5. From a point in the same horizontal plane with the base of a tower, the angle of elevation of its top is 50° 39′; and from a point 100 ft. further away it is 35° 16′. Required the height of the tower.

Duties.

Questions relating to the implements, materials and methods used in making maps and plans. Details of plans, such as lettering titles, coloring and ornamenting; scales, north points, etc.

Methods of duplicating, preserving and cleaning plans, etc.

Tracing.

Same as Division A.

Plotting.

Plotting a survey by co-ordinates from field notes, inking in plot and lettering a title.

Sample Question.

Plot accurately, on a scale of 30 ft. to an inch, the survey of a parcel of land given in the following notes:

Station.	Bearing.	Distance.
1.	N. 48° 30′ E.	213.00 feet.
2.	S. 42° 15′ E.	193.80 "
3.	S. 49° 15′ W.	162.00 "
4.	N. 82° 15′ W.	77.40 "
5.	N. 42° 45′ W.	133.20 "

Locate station one 5½ in. from the bottom of the drawing paper and two inches from the left margin.

Ink-in the plot, mark the bearing and length of each side, draw a north point and letter the following title, making your own arrangement: "Plan of land in Boston belonging to John Smith, March, 1898. Scale, 30 ft. to an inch."

Drawing.

This subject calls for the making of a detailed drawing of an engineering structure, the whole to be finished in India ink and neatly lettered. A rough sketch will be furnished, giving the general dimensions of the structure, and such other data will be supplied as a chief draftsman or designer in actual practice would give to his assistant to enable him to prepare a set of working drawings.

In examinations already held, the applicants have been required to make the drawings of a masonry abutment for a highway bridge.

CIVIL SERVICE OF THE CITY OF NEW ORLEANS, LA.

INSTRUCTIONS TO APPLICANTS.

I. General Instructions.

Candidates for any Civil Service position under the government of the City of New Orleans, should, first of all, carefully read the printed rules of the Board. These will answer many questions, and a careful reading of them will prevent many mistakes. Should any additional information be desired, it may be obtained at the office of the Board, which is always open within legal hours.

2. Persons Who Will Not Be Examined.

No person will be admitted to examination:

(*a*) Who is physically disqualified for the kind of service he seeks;

(*b*) Who habitually uses intoxicating liquors to excess;

(*c*) Who is enlisted in the army or navy.

(*d*) Who has been dismissed from the service of the City of New Orleans for good cause.

3. Obtaining and Filling Out Application Blanks.

No person will be admitted to examination who has not previously filed an application for the particular examination which he seeks on the application blank prescribed by the Board. Each applicant must apply for his own application blank, as it is contrary to the rules of the Board to furnish blanks to one person for the use of another person.

The certificate of vouchers required in the application papers are of the utmost importance. Applicants should seek as vouchers persons who have practically known them in their callings. The certificates of persons of distinction in politics are of weight, only so far as they show real or close knowledge of the candidate, and the Board's action can in no way be biased by the political influence, real or supposititious, of the signers.

Full instructions for the execution of the application will be found on the blank itself, and applicants are cautioned to answer all questions and conform in all respects to the printed instructions. A failure to do this causes delay and annoyance.

Applicants will not be admitted to examinations who have not complied with the requirements of other proper authority in advance. An application will be good for only one kind of examination, and if an applicant desires to take more than one kind of examination he must file a separate application for each kind desired.

In the case of foreign-born citizens proof of citizenship must be furnished. If naturalized, a certificate of naturalization must accompany the application. A foreign-born person who claims that his parents were citizens of the United States at the time of his birth must furnish evidence in support of his claim. A foreign-born citizen who was naturalized by the naturalization of his father or his mother, while he was a minor, must furnish his father's certificate of naturalization, and evidence of his identity as the child of the one whose certificate is furnished. A woman who claims naturalization through marriage to a citizen of the United States must furnish evidence of the husband's citizenship (his certificate being required if he is a naturalized citizen) and evidence of her marriage to him.

An application from a foreign-born person claiming citizenship, but failing to furnish the required proof, will be cancelled. A declaration of intention to become a citizen will not be accepted in lieu of a certificate of naturalization. When naturalization papers are lost a certificate must be procured from the court that issued the naturalization papers, showing the facts in the case.

Persons who have been indicted or convicted of any offense must enclose with their application a statement showing the essential facts of the case.

All applications which show the applicants to be ineligible on any account will be cancelled and retained in the files of the Board. All applications which are defective in their execution and can be corrected by the applicant will be returned for correction, but an application which has been twice returned for correction and is still found to be incomplete will be cancelled.

Applications which have been approved or cancelled, and all examination papers of competitors form a part of the official records of the Board, and cannot, under any circumstances, be returned to the applicants.

4. Period of Eligibility.

The period of eligibility expires January 31st of each calendar year.

5. Record of Standing of Competitors.

A record of standing will be furnished to each person examined, whether he passes or fails to pass.

6. Change of Address.

Applicants and eligibles must keep the Board informed of any change of post-office address. A failure to do so may easily result in the loss of an opportunity for appointment.

7. Waiver of Certification.

An eligible may, upon giving to the Board in writing satisfactory reasons, waive certification without losing his eligibility.

8. Effect of Declining Appointment.

An eligible who declines an appointment tendered him will not again be certified unless he shall request in writing a further certification, stating reasons, which must be satisfactory to the Board for declining the appointment.

No person shall be considered a bona-fide resident of the City of New Orleans for one year prior to his employment.

All the permanent employees of said Board, who are required to be appointed after civil service examination, shall be of good moral character, and bona-fide residents of the City of New Orleans for at least one year prior to their appointment. Said Board shall have power, and it shall be its duty, to demand and require bonds with good and sufficient surety for the faithful performance of their duties from all of its employees who handle money or material, or who fill positions of responsibility.

CIVIL ENGINEERING POSITIONS IN THE OFFICIAL SERVICE.

Tracers, at salaries less than $600 per annum.

Positions involving a knowledge of drafting, at salaries of $600 per annum, or more, and not greater than $1 000 per annum.

Draftsmen, with salaries of $800 per annum, or more, and not more than $1 000 per annum.

Draftsmen, with salaries of $800 per annum, or more, and not more than $1 200 per annum.

Positions involving a knowledge of topographical drafting, with salaries greater than $1 000 per annum.

Positions involving a knowledge of architectural drafting, with salaries greater than $1 000 per annum.

Levelmen.

Rodmen.

Paving Inspectors.

Superintendent of Architecture, Department of Engineers.

Chief Inspector Sewerage System.

Chief Inspector Water Supply System.

Inspectors Sewerage System.

Inspectors Water Supply System.

SPECIMEN EXAMINATION PAPERS.

BUILDING INSPECTORS.

Arithmetic.

1. Multiply $3\frac{3}{8}$ by $41\frac{5}{81}$.

2. Reduce .3125 to 16ths.

3. Bought a number of barrels of lime and used 84% for mortar; there are 32 bbls. left. How many barrels were bought?

4. Find the square root of 611424.

5. If sound travels 6 160 ft. in $5\frac{1}{2}$ sec., how far will it travel in one minute?

Practical and Technical.

1. What is the safe load per square foot on foundations in New Orleans?

2. Describe the best method of building brick foundations?

3. (*a*) What are the best materials to use for concrete, and what are the best proportions for same? (*b*) What is the best method of mixing and laying concrete? (Describe how this is done so as to insure best results if the materials and proportions are all right.)

4. What is done to prevent dampness of the ground from rising in brick walls and what is the best way to do it?

5. Give the names of five (5) of the best high-grade German or American Portland cements?

6. Describe two (2) methods of bonding pressed brick work and state which, in your opinion, is best?

7. Does lumber shrink in length and breadth and thickness, or in only one or more of these dimensions?

8. What is a cantilever beam?

9. Why is it necessary to use traps to the waste-pipe of plumbing fixtures? How are the traps ventilated?

10. How are the plumbing pipes tested to make sure that they are tight?

11. How far apart should laths be placed to insure proper keys for plastering?

12. What number of galvanized iron should be used for an eight (8″) inch ogee gutter?

13. What lap should be given to slates for quarter-pitch roof?

14. The formula for the ultimate strength of pine beams supported at both ends and uniformly loaded is $\frac{4\,R\,b\,d^2}{3\,L}$;

$$\begin{aligned} R &= \text{modulus of rupture} = 7\,300 \text{ lb.}; \\ b &= \text{breadth in inches}; \\ d &= \text{depth in inches}; \\ L &= \text{length in inches}. \end{aligned}$$

What is the breaking load uniformly distributed on a pine beam 6 in. by 8 in. by 12 ft. 0 in. which is supported at both ends? What factor of safety should be used and what is the safe load?

15. What should be the thickness of the walls of each story of a 5-story brick building?

SPELLING.

Pavilion	Oriel	Advisable
Chargeable	Collateral	Parallel
Forfeit	Guarantee	Miscellaneous
Negotiable	Promissory	Recommend
Birch	Frieze	Grotesque
Sphinx	Mausoleum	Interstice
Astragal	Unsymmetrically	

GENERAL SUPERINTENDENT, PUBLIC WORKS.

PRACTICAL QUESTIONS.

1. What are the duties of the General Superintendent of the Public Works Department?

2. Explain what are done with complaints reaching the Department?

3. With what tools does the Department furnish its workmen?

4. What extent of asphalt roadway and contiguous stone pavements has it been found by experience that one man can keep clean?

5. What is the price per day of driver, animal and cart?

6. What improvement on the present style of carts collecting garbage might be proposed for economical and better service?

7. With the present style of carts removing street pilings, is it proper to attempt to remove slush and soft mud at the moment of removal from gutters?

8. What check for proper amount of work for a day's hauling should be applied to the work of a cartman?

9. What new public work now about to be constructed might facilitate the removal of gutter pilings from the front of our city?

10. Would it be possible to have the pilings sell for about the cost of their removal from the gutters and streets?

11. How many feet, board measure, in the following:

7	pcs.	6″	×	8″	×	18′
9	"	2″	×	12″	×	15′
6	"	3″	×	9″	×	12′
3	"	3″	×	4″	×	20′
5	"	4″	×	6″	×	15′

12. Explain how to obtain the volume or capacity of a cart?

13. How many barrelfuls in a pile of lake shells having a volume of 1 220 cu. ft.?

14. With what kind and size of nails are 3-in. planks fastened?

15. How might economy be exercised concerning the present method of attendance on the turn-bridges in charge of the Department, and state the possible economy in each instance?

Letter Writing.

Write a letter of not less than 150 words concerning the collection and disposal of garbage.

Arithmetic and Mensuration.

1. Add

$$\begin{array}{r} 932576418 \\ 4394287 \\ 56431979 \\ 60356 \\ 798795 \\ 40019 \end{array}$$

2. Multiply 7896537 by 8973

3. Divide 239786509 by 799

4. From $\frac{1}{5}$ of $\frac{3}{8}$ of $2\frac{1}{3}$ take $\frac{3}{8}$ of $\frac{1}{6}$.

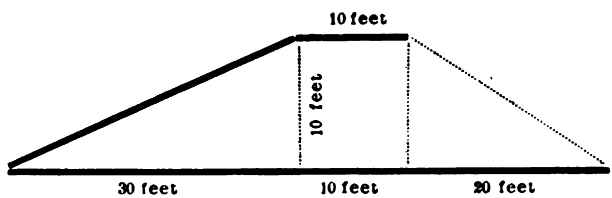
5. What is 17% of \$2 789?

6. If three men can lay 4 000 bricks in two days, how many men can lay 12 000 in 3 days?

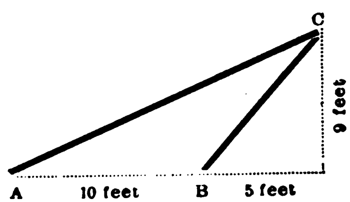
7. If the area of a circle whose radius is 1 ft. equals 3.1416 ft., what is the area of the circle in square yards whose radius is 5 ft.?

8. Find the volume in cubic yards of a right cylinder whose end area is the answer to the preceding question and having a length of 9 ft.

9. If the cross-section of a level is of the following form and dimension, and 105 ft. long, what is its volume in cubic yards?



10. A triangle $A\ B\ C$ of the following shape has the dimensions and other measurements relative thereto as marked in feet. Find its area in square feet.



Spelling.

Wharves	Collection	Recede
Barricade	Asphalt	Supervisor
Supersede	Separate	Balance
Rendezvous	Metairie	Avidity
Corrodible	Discussion	Empirical
Fallible	Grievance	Libelous
Nausea	Querulous	

ARCHITECTURAL DRAFTING.

Arithmetic.

1. Multiply $7\frac{1}{8}$ by 26, 126 4-17.

2. Reduce .4226 to 15ths.

3. A man owns $\frac{2}{3}$ of a property; 35% of his share is worth $1 500. What is the value of the property?

4. A note was given on August 5, 1902, and was paid on March 9, 1904. How long did it run? What is the total interest in that time at 6% per annum?

5. What is the square root of 3426201?

Drawing.

The applicant shall copy the accompanying blue-print as neatly and as accurately as possible.

The drawing shall be in pencil (not inked). The following title shall be placed on the drawing:

Example of Roman Doric.

Schedule B 6. No. February 3, 1905.
Architectural Drafting. New Orleans, La.

Letters to be in free-hand and in pencil with Capitals 3-16 in. high and small letters 7-32 in. high.

Geometry and Mensuration.

1. A circular tank measures 6 ft. in diameter, and is 8 ft. 6 in. high; bottom of overflow pipe is six in. (6 in.) from top of tank.

How many pounds of water does the tank contain?

(One gal. of water weighs 8.35 lb., and there are 7.48 gal. of water per cubic foot.)

($\pi \doteq 3.1416$.)

2. What length of stone coping is required for a gable the width of which is 32 ft. and the height $\frac{3}{4}$ of the span?

3. What angle does the minute hand of a clock travel in 10 minutes?

4. A hollow circular cast-iron column has an external diameter of 8 in. and is required to carry a load of 47 120 lb., and should be loaded 4 000 lb. per sq. in. What thickness of the metal ring is required?

5. If brick masonry can carry 10 tons (of 2 000 lb.) per sq. ft., what must be the area of the plate under the same column and resting on masonry?

Letter Writing.

Subject: A description of a beautiful building which the applicant is supposed to have seen, or has seen.

This letter should contain at least 125 words.

Spelling.

Acanthus	Presbytery	Pilaster	Escutcheon
Caryatides	Finial	Stanchion	Crypt
Gargoyle	Andirons	Israelite	Quoin
Corinthian	Chalice	Pinnacles	Triglyph
Medieval	Pargeting	Cantilever	Tympanum

Plain Copy.

Which will also serve as the Test of Penmanship.

The mind of man naturally hates everything that looks like a restraint upon it, and is apt to fancy itself under a sort of confinement, when the sight is pent up in a narrow compass, and shortened on every side by the neighborhood of walls or mountains. On the contrary, a spacious horizon is an image of liberty, where the eye has room to range abroad, to expatiate at large on the immensity of its views, and to lose itself amidst the variety of objects that offer themselves to its observation. Such wide and undetermined prospects are pleasing to the fancy, as the speculations of eternity, or infinitude, are to the understanding.

Spelling.

Accident	Forget	Opposite
Beggar	Gamble	Prepare
Censure	Inquire	Quiet
Collision	Incompetent	Refer
Disobedience	Innocent	Suspect
Disperse	Judicial	Witness
Effect	Market	

CLASS A. SCHEDULE B 8.

Rodmen.

The applicant is required to make an identical copy of the following. Be particular, while so doing, as it is for a test of your penmanship and ability to make copies of communications:

Plain Copy.

Portland cement is made from artificial mixtures of clay and chalk burnt and ground to powder. Natural limestone containing

the requisite proportions of these ingredients is, however, found and used in some localities. The cement derives its name from its similarity, when set, in both hardness and color to Portland stone. It is used where no special haste in construction is to be exercised and where great strength is required.

A good quality of Roman cement is made from natural stone nodules found in clay of the city of London. It is valuable on account of its quick-setting properties, usually becoming hard in 15 minutes. It is much used for tidal work. Roman cement does not admit of storage for long periods.

Arithmetic.

1. Add 79.8336; 234.657; 293.52; 7.8; 1937.54 and 837.4327.

2. Subtract 385.5793 from 395.28.

3. Multiply 3486.345 by 76.58.

4. Divide: 47957813.86 by 837.963.

5. Add $\frac{2}{3}$ of $\frac{7}{9} \times \frac{3}{5}$ to $5\frac{3}{4} \div \frac{4}{5}$.

6. Reduce $\frac{3}{8}$ and $\frac{7}{8}$ to decimals.

7. What is 3% of 1 000 ft.?

8. How many feet and inches in 25 links of a gunthers chain?

9. What is the difference between 4 sq. ft. and 4 ft. square?

10. How many granite blocks, 12 in. by 18 in., will be required to pave a mile of roadway 42 ft. in width?

Mensuration.

1. How many square yards of pavement in the intersection of two sidewalks, one 12 ft. wide and the other 10 ft. wide, less the thickness of steel concrete curbing which is 6 in.?

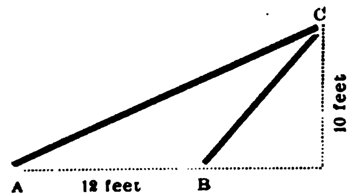
2. How many superficial square yards 6 in. thick can be made from a cubic yard? How many superficial feet 6 in. thick can be made from a cubic yard?

3. A lot is 30 ft. wide by 120 ft. deep and surface is level. If 9 in. fill is fixed at the front line and 20 in. at the rear line, what is the average depth of fill, and how many cubic yards are required to fill the lot?

4. Allow $\frac{1}{5}$ of the yardage of above for settlement and 2 cu. yds. hauled in 3 loads. How many loads will be required to fill the lot so

that when ultimate settlement has taken place, the lot will be at proper grade?

5. Find the area of a scalene triangle *A, B, C,* having the accompanying figure:



SPELLING.

Hatchet	Level	Stall	Version
Stakes	Height	Tyranny	Visible
Distances	Tedious	Totally	Welcome
Weeds	Tenement	Uncivil	Warrant
Bushes	Recreant	Polite	Wriggle

CHICAGO, ILL.

CIVIL SERVICE EXAMINATION QUESTIONS FOR STRUCTURAL IRON DESIGNERS.

Oct. 26, 1900.

Experience.

State what experience you have had to qualify you for the position of structural iron designer. Give dates, names of employers, and length of service.

1. Fig. 1 shows the stress sheet of a 130-ft. span; what will be the approximate weight of metal? Indicate method used for obtaining result.

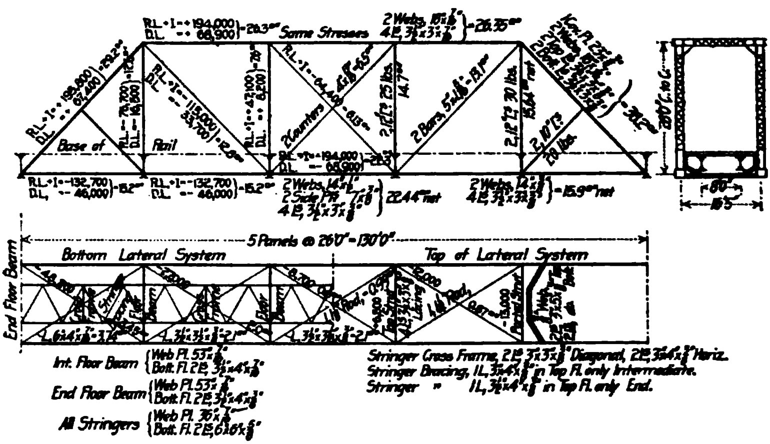


Fig. 1.

2. Calculate size of pin necessary for the connection shown in Fig. 2, assuming that 20 000 lb. per sq. in. are allowed in bending and 15 000 lb. per sq. in. in shear. Give details of calculation. Graphical method may be used.

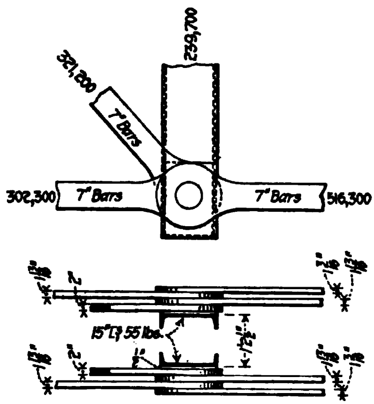


FIG. 2

3. A span of 80 ft. is required to carry street traffic. No limit is placed for the depth of the structure. Distance between centers of main girders is 24 ft. The pavement is to be cedar block laid on 4-in. planking, the latter resting directly on the steel floor. Assuming a moving load of 100 lb. per sq. ft., design the most economical floor, using steel floor beams and steel stringers and straining them not more than 12 000 lb. per sq. in. in the extreme fiber. Pencil sketches only will be required showing outline, sizes and dimensions. State weight of steel floor per linear foot of bridge. Give also the sectional material for the main girders.

4. An inclined end post, shown in Fig. 3, carries a total stress of 440 000 lb. The web is $\frac{5}{8}$ in. thick, and there is only room for one $\frac{1}{2}$-in. pin plate or hinge plate on the inside of each web. Assuming 18 000 lb. per sq. in. to be the permissible limit for bearing on pins, 7 500 lb. per sq. in. to be the limit for shear of rivets and 15 000 lb. per sq. in. to be the limit for bearing on rivets, calculate the size and number of pin plates, the number of $\frac{7}{8}$-in. rivets required, and show their arrangement for a $6\frac{1}{2}$-in. pin.

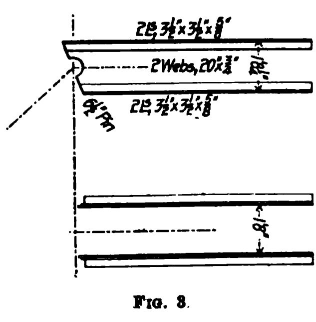


FIG. 3.

5. Do you consider a stiff or an adjustable lateral system as preferable for bridges? State your reasons.

6. A column fixed at the base is to carry a fixed load of 100 tons applied centrally and 10 tons applied eccentrically, 2 ft. from the center at top. Height of column, 40 ft. May be built of channels, Z-bars or plates and angles. Calculate column by any standard formula and give sketch of section with sizes and dimensions; also details of calculation and reasons for adopting the form of section.

7. What size and shape lattice bars would you use for a compression member built of 2 webs 30 by $\frac{3}{4}$ in. and 4 angles 6 by 6 by $\frac{3}{4}$ in., distance back to back of angles being 20 in.?

8. Describe, without going into details, how you would design the following structure: A 200-ft. highway span over railway track with viaduct approaches, as shown in Fig. 4. Bed rock, 6 ft. below surface of ground. The headroom over tracks to be 20 ft. under 200-ft. span. Top of floor to base of rail not to exceed 23 ft. No limitation as to headroom under approaches. Roadway to be 40 ft. wide in the clear between curbs, with two 6-ft. sidewalks. Indicate in writing the principal characteristics of each portion of the structure, such as length of spans, columns, girders, floor, bracing, etc., assuming that the highest class of structure is required.

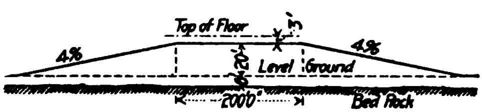


FIG. 4.

9. What is the relation between the deflection of a beam of equal resistance, or one which has a constant extreme fiber strain throughout its length, and the deflection of a beam of constant moment of inertia, all other conditions being equal?

10. Being given a continuous beam of 3 equidistant supports uniformly loaded, what is the end reaction expressed in terms of the total load?

The applicants may use a Carnegie "Pocket Companion" for reference in answering the above questions.

CIVIL SERVICE EXAMINATION FOR STRUCTURAL-IRON DESIGNERS AT CHICAGO.

JANUARY 1ST, 1903.

EXAMINATION QUESTIONS.

MATHEMATICS.

1. What would be the weight of a solid column 10 ft. long and 9 in. diameter if made of (*a*) cast iron; (*b*) wrought iron; (*c*) steel?

2. What should be the area in cross-section of a steel strut 1 ft. long that is to carry a load of 10 tons with a factor of safety of 4?

3. How many feet B. M. (*a*) in a floor 10 ft. wide by 120 ft. long made of 3-in. oak planks; (*b*) in an oak timber 6 by 14 in. and 18. ft. long?

4. What should be the diameter of a wrought-iron rod which is to stand a tensile strain of 7 000 lb. with a factor of safety of 7?

5. What is the moment of inertia of a box girder 7 in. square outside measurement and made of metal ½ in. thick?

DUTIES.

1. In braced portal, Fig. 1, find reactions and strains in rods.

2. In plate girder, Fig. 2, find spacing of rivets for a distance of 4 ft. from end "A"; also spacing of rivets between points X and Y. Allow 3 500 lb. bearing and 3 000 lb. for single shear per rivet.

3. In pony truss, Fig. 3, find maximum strain in members 1-3 and 1-4 for loads, as per diagram, moving over bridge.

4. In the same pony truss, what are the strains in members 3-4, 5-6, 3-6 and 5-4 for a panel dead load of 5 000 lb. when both diagonals are stiff members.

5. Find maximum bending moment on pins shown in Fig. 4.

6. In section shown in Fig. 5, find the radius of gyration around axis X-X; correct to two decimals.

7. Find section modulus "S" of section shown in Fig. 5.

8. In sidewalk bracket, Fig. 6, find the strain in member A-B.

9. Find the number of rivets required for member A-B in sidewalk bracket, Fig. 6. Member composed of two angles. Allow 3 500 lb. bearing and 3 000 lb. for single shear per rivet.

10. Find deflection at center of beam shown in Fig. 7.

NOTE.—Figure numbers refer to diagrams which were furnished to candidates.

JANUARY 21ST, 1904.

AN EXAMINATION OF CANDIDATES FOR CHIEF SANITARY INSPECTOR OF CHICAGO

was held in that city on January 13th. Some of the questions on general sanitation and hygiene were as follows:

Explain the germ theory of disease in its modern aspects.

What are the most prevalent diseases in cities and by what sanitary measures can they be most effectively combated?

What is the latest opinion concerning the dangers to health from leaky plumbing and broken drains?

What are the dangers of poisoning from small quantities of illuminating gas?

Why is it important to secure the drainage of wet places and the removal of stagnant water about dwellings?

What role do insects, such as flies and mosquitoes, play in the transmission of infection?

How does defective tenement-house construction facilitate the spread and maintenance of infection?

What is the scope of work of a sanitary bureau, and what is it intended to accomplish?

What measures, in your opinion, are most likely to aid in improving the sanitation of a large modern city?

What, precisely, do you understand by the term "cleanness," as applied, for example, to streets and alleys, to schoolhouses and other public buildings and to the ordinary dwelling-house?